MONTHLY WEATHER REVIEW

AUGUST, 1931

CONTENTS

CORRECTIONS

Volume 59, June, 1931, page 219: The correct title of the article on this page is, "Ground Plan of a Dynamic Climatology."

Volume 59, June, 1931, page 228: The illustration marked "Fig. 8" should read, "Figure 5.—Distribution of wreckage at the Quinn ranch at the mouth of Tree Canyon, about 6 miles southwest of Gothenburg."

The three tornado illustrations on the opposite page should bear the numbers "6," "7," and "8," respectively. The legend to Figure 6 should read, "Funnel dropping on Quinn ranch at Tree Canyon, 5 miles southwest of Gothenburg. Photograph take from a point one-half to three-quarters of a mile east of the funnel, by Mrs. Roy Homer." The other two legends are correct, except that the numbers should be "7" and "8," respectively.

MONTHLY WEATHER REVIEW

SOME PROBLEMS OF THE BOULDER CANYON-COLORADO RIVER DEVELOPMENT

By JOHN L. BACON, Chairman, California-Colorado River Commission

June 15, 1931.

The Colorado River, like all streams flowing through a semiarid country, has periods of extreme high and low flow. These periods are of annual occurrence and are fairly uniform both as to amount and time. During the periods of high water a serious flood condition exists along the lower reaches of the river that at times is an acute menace. During the low-water periods there is sometimes an absolute water shortage, with not enough water to supply the existing demand for irrigation and domestic purposes. This low-water flow naturally limits the demand that may be satisfied from the river, and the limit has been reached.

The variation in the flow of the Colorado is very great. Many seasons the flood has reached a flow in excess of 200,000 cubic feet per second, and during the dry season this flow has dropped below 2,000 second-feet. About 5,000 or 6,000 second-feet of flow is required to satisfy the demand at and below Yuma.

One condition exists that is peculiar to this river—the largest single area using water lies entirely below sea level. The Imperial Irrigation District, comprising over half a million acres, lies in what at one time was the end of the Gulf of California. Silt brought down by the Colorado formed a delta across this arm of the sea, extending across the entire width of the valley, from the present bank of the river in Arizona to the high hills along the western side of the valley in California. Silt formed the valley and now threatens to destroy it by the continual building up of the delta and the forcing of the river into new channels that have a constantly increasing tendency to flow back into the valley below.

The amount of silt coming down the river every year is about equal to the total amount of excavation the Americans dug out of the Panama Canal. To prevent the mouth of the river being diverted down the northern slope of the delta and back into the Imperial Valley by the ever-increasing deposit of silt, the Imperial Irrigation District has been compelled to maintain an ever-lengthening system of dikes or levees along the lower reaches of the river in Mexico. To-day there are about 75 miles of these levees in use, and some 21 miles in addition have been built, which have either been destroyed by the river or abandoned on account of improper location.

The elevation of the delta, where the river is flowing, is some 50 to 75 feet above sea level, while the Salton Sea, which fills the bottom of the bowl forming the Imperial Valley, has a surface elevation of about 250 feet below sea level.

In addition to the natural difficulties encountered on the Colorado there are many and grave political complications. The Colorado flows through the States of Arizona, Nevada, New Mexico, Utah, Colorado, and Wyoming and borders on California for some 250 miles. From the international border line the river flows through Mexico before entering the Gulf of California, and considerable water is used there for irrigation. There are vast areas in each of these States, as well as Mexico, whose every interest is entirely dependent upon the water obtained from the Colorado. Each of these areas is jealous of development in other areas and will go to almost any length to protect real or fancied opportunities of future development.

We have, then, not only an interstate but an international complication. We have no treaty with Mexico regarding allocation or use of Colorado River water. There is no agreement between the States making a definite allocation of use between individual States, although the so-called Colorado River compact does make an allocation of use between two groups of States known as the upper and lower basin States. Roughly, the States of Arizona, California, and Nevada comprise the lower basin and the States of Utah, Colorado, Wyoming, and New Mexico the upper basin, although portions of some of the States overlap both basins.

Problems on the Colorado were really brought to an acute head by conditions in the Imperial Valley. When irrigation and settlement first started in 1902 little attention was paid to the delta conditions and water was diverted through an old stream bed running along close to the top of the delta, starting at about the intersection of the Colorado with the international boundary line, looping down through Mexico, and crossing back into the United States about 40 miles west of the Colorado.

The promoters had a concession from the Mexican Government under the terms of which Mexican lands were to have half of the water flowing in the canal at any time.

Some 13 years ago the people of Imperial Valley, realizing that serious conditions were developing and that the problems were becoming too serious for them to handle, went to Congress and asked for aid. The first step was a bill to construct what was known as an All-American Canal to connect the Colorado River with the Imperial Valley and relieve the valley of the ever-increasing international complications that were developing. This bill was not passed, but it did, along with other bills which succeeded it, rouse sufficient interest so that Con-

gress in 1920 authorized a thorough investigation and report of the conditions on the Colorado with the view of determining some possible solution of the ever-increasing difficulties.

The result of the above investigation was a report rendered in 1920, known as the Fall-Davis report, recommending the construction of the Boulder Dam, afterward named the Hoover Dam. As set forth in the report, the object of such a dam was to provide sufficient storage to impound an entire year's run-off of the Colorado, and then feed this stored water downstream for use when needed, thus utilizing the flood waters that had been running to waste and making them available when most needed during the dry periods. It also recommended that the waters from the dam be passed through a power house and that the energy thus generated be sold, it being believed that the income from this source would be sufficient to repay the entire cost of the investment. An all-American canal was also recommended to carry water from the river to the Imperial Valley and replace the present canal in Mexico.

This was the solution offered by the Government engineers, and so well was it worked out that, though numerous other investigations have since been made and many other reports rendered, the development as it is going ahead to-day practically follows the recommendations made in the Fall-Davis report.

Briefly, the situation might be summed up in this way: The conditions were laid before the Reclamation Department and after careful investigation the answer came back—build Boulder Dam. The object to be attained was to control the river, store the floods, and feed down the water when needed, and in the process of feeding down the water run it through a power house and let the drop of the water pay for the cost of control by selling the power thus generated.

After numerous failures to obtain favorable action by Congress, the so-called Swing-Johnson bill was passed, authorizing the construction of a dam in the Colorado River at Black or Boulder Canyon, the construction of a power plant below the dam, and the building of the All-American Canal. This bill passed December, 1928, and the first appropriation was authorized in the deficiency appropriation bill signed by President Hoover July 3, 1930.

These are only a few of the high points among the events leading up to the start of the Hoover Dam.

The financing of the project and the actual construction present many interesting and big problems. Before work could start the Secretary of the Interior was compelled by the terms of the act to have contracts for the disposal of the power that would guarantee to the Government the full repayment of all money invested plus interest at 4 per cent. This was accomplished. An immense river must be diverted from its bed and carried around the actual site of the dam. The structure will be the largest block of concrete ever cast. The mere financing of the construction work by the contractors is no mean proposition.

The Boulder Dam, as it has been popularly known, or the Hoover Dam, as it is now and will hereafter be officially known, is to be an arch gravity section concrete dam in the Colorado River about 250 miles upstream from the point where the Colorado crosses the international boundary line between California and Mexico. The location is about 150 miles below the limits of the Grand Canyon National Park. These distances are measured along the river and would be slightly shorter if taken in a direct line. It is about 30 miles southeast of Las Vegas, Nevada, the nearest city. The river at this point runs through a deep, narrow gorge over 1,000 feet deep, that almost looks as though nature had provided it for this particular purpose.

The dam will be over 700 feet high from bedrock to top, will impound over 30,000,000 acre-feet of water, creating the largest artificial body of water in existence behind one dam, and will make an artificial lake over 100 miles long.

The financing of the project has proven an extremely interesting problem. The act provided for considerable latitude. The Government could either lease the right to use the falling water, it could build a power plant and lease the plant or units of the plant, or it could build and operate the plant and sell the power thus generated at the switchboard.

A sort of combination of these methods was finally worked out, and under the final contracts the Government is to build the building housing the power plant and control the water up to the control valves, the lessees pay for the generating machinery and operate it, and pay the Government for the use of the falling water, the rate of payment to be governed and measured by the amount of water required to generate a kilowatt of electrical energy at the switchboard at the plant. The rate to be paid is 1.63 mills per kilowatt-hour for primary or firm power and 0.5 mill for secondary or what might be termed "spill" power. There will be other items of income, but the income from power alone during the 50-year amortization period of the dam will yield an average of over $7,000,000 per year. Of this income Arizona and Nevada will *each* receive over $600,000 annually, without the expenditure of anything on their part.

During the 50 years in which the dam and all expenditures must be paid for, with interest at 4 per cent, the income will be sufficient to pay all capital costs, operate and maintain the works, provide for depreciation, pay the interest, pay the amounts given above to Nevada and Arizona, and in addition provide a fund that may be used for general development of the Colorado of over $66,500,000. The initial cost to the Government, including $11,554,000 to be charged for interest during construction period, is estimated at $121,000,000. In addition the All-American Canal, estimated to cost about $32,000,000, will be a separate financial set-up.

Perhaps the most novel feature of the construction of this huge dam is the method to be used to carry off the heat generated by the chemical combinations and reactions of the setting cement. Very little attention is ordinarily paid to this in common practice, as the mass of the setting concrete is generally small enough to permit the radiation of the heat generated without any difficulty; but in the case of the Hoover Dam, where the mass is over 600 feet thick in some places, the carrying off of this heat becomes a real problem. A method or refrigeration, or artificial cooling, has been worked out to take care of the unusual conditions brought about by the great mass of the concrete and by the rapidity of pouring. (It is expected to pour concrete at the rate of 3,000 yards per day.) Shrinkage takes place in the mass until the heat generated by setting has been dissipated.

The following data have been furnished by the Denver office of the Reclamation Department:

The object to be obtained by artificially cooling the concrete during the setting period is to dissipate its setting heat in a rela-

tively short period of time, so that the resultant shrinkage of the mass will take place before it is necessary to pressure grout the construction joints and impound water behind the dam. The chemical action in setting concrete develops a large amount of heat, which heat is rapidly dissipated by radiation when in masses of small dimensions. On the other hand, this heat radiation from large masses is relatively very slow and varies as the square of the dimensions of the mass. On this basis the degree of cooling that would naturally take place by radiation from a mass 50 feet in thickness (a representative dimension for concrete arch dams of ordinary magnitude) in one years' time would require a century if the structure were 500 feet thick, which may be taken as the average thickness of the Hoover Dam. Shrinkage in the mass will continue until the setting heat is dissipated. To correct for this and to make the structure monolithic and water-tight, the contraction joints provided for this purpose will be filled with cement grout under pressure after the cement has cooled. The artificial cooling is therefore required in order to permit the completion and use of the dam within a permissible period of time. The rated capacity of the cooling plant is 600 tons per day.

The circulating pipes in the concrete are to be spaced 10 feet apart vertically and about 11½ feet apart horizontally. The approximate basis for estimating the amount of heat to be removed is 50,000 to 60,000 B. t. u. per cubic yard of concrete as an average condition. Data of record relative to the thermal properties of concrete are comparatively meager and, in some instances, apparently erroneous. A suitable series of experiments will be conducted to establish these properties for the specific materials to be used before concrete placing is begun.

The injurious effects to be anticipated if no provision were made for artificial cooling are the cracking of the concrete and the opening up of the construction joints due to shrinkage from cooling after the structure is completed and put in use. Such cracks and open construction joints would invite leakage and would disarrange the distribution of stresses between the arch and cantilever elements, which would result in concentrated stresses much higher than calculated in the design of the dam due to the structure not being able to act as a monolith.

The turning of the river to permit the unwatering of the actual dam site is no mean undertaking. To do this, four tunnels are to be driven, two on the Nevada side and two on the Arizona side of the river. The bottom elevation of these tunnels will be about the low-water flow line of the river. Each tunnel will be about 50 feet in diameter when finished, and the combined capacities of all four will be about sufficient to take care of the average flow of the Mississippi River at St. Louis. The capacity will be 200,000 cubic feet of water per second. When these tunnels are completed, cofferdams of rock-fill construction, faced upstream with steel-pile cut-off walls, will be constructed, one just below the upstream

intakes and one just above the downstream discharge ends of the tunnels. These cut-off dams will raise the water at the upstream end and divert the flow of the river through the completed tunnels, and the downstream dam will prevent the water from backing up and flooding the site.

After the main dam is completed, all four of the tunnels will be plugged at the upstream ends. One tunnel on each side of the river will be used for a spillway by connecting with a slanting shaft having its upper end at the water surface of filled reservoir. The other two tunnels will be plugged at both ends and will be utilized as pressure tunnels to connect with the control gates in the inlet towers.

SOME FIGURES ON THE HOOVER DAM

In order to gain some conception of the magnitude of this great project it does not seem out of place to list some of the items that will enter into it.

Tunnels.—Combined length, 3.1 miles; cubic yards of excavation in rock, 1,900,000.

Cofferdams.—1,200,000 cubic yards of rock and earth fill.

Reinforcing steel bars and rails.—35,500,000 pounds.

Concrete.—4,400,000 cubic yards.

Miscellaneous items.—Small metal pipe and fittings, 1,900,000 pounds; structural steel, 10,600,000 pounds; large metal conduits, 32,500,000 pounds; metal work, gates, hoists, etc., 20,000,000 pounds.

Time to build.—About six or seven years.

It is estimated that it will require about 350 carloads of material daily to keep up with the demand for supplies during the construction period.

Even the seemingly simple element of elevator service looms rather large when it is realized that enough workmen to man a good-sized manufacturing plant must be handled in and out of a canyon over a thousand feet deep.

This dam will be the Government's answer to a series of vexing problems that have developed in connection with the river and will, as has been aptly said, "Convert a natural menace into a national resource" and will mark one more milepost in man's struggle against nature.

SOUNDING-BALLOON OBSERVATIONS MADE AT BROKEN ARROW, OKLA., DURING THE INTERNATIONAL MONTH, DECEMBER, 1929

By L. T. SAMUELS

[Weather Bureau, Washington, D. C., July, 1931]

In cooperation with the International Commission for the Exploration of the Upper Atmosphere the Weather Bureau conducted a series of sounding-balloon observations at the Broken Arrow [1] (Okla.) aerological station during the international month, December, 1929. The instruments used were of the Fergusson type. The balloons were made of seamless rubber and weighed between 575 and 1,238 grams. They were spherical in shape, between 75 and 100 centimeters diameter, and were inflated to between 137 and 158 centimeters diameter. This gave a free lift of approximately 500 grams and an ascensional rate of about 238 meters per minute.

The balloons were released daily about one hour before sunset so as to eliminate, so far as possible, the effects of

insolation on the meteorograph and still make possible the use of theodolites to follow the balloons. On the 17th, 18th, and 19th (international days) additional balloons were released shortly after sunrise. There were 34 observations made, and 26 (76 per cent) of the instruments were returned. One of the latter had the record sheet removed and another had a faulty pressure record. Of the eight instruments not returned, three were followed with two theodolites to the following heights, viz, 13,175 meters on the 2d, 7,420 meters on the 26th, and 17,590 meters on the 30th. Wind velocities and directions were determined to those elevations.

The balloons were followed with two theodolites whenever possible, and in nine cases these continued for 60 minutes or more, the longest run being 90 minutes on the 25th.

The altitudes as determined from 2-theodolite observations and those obtained hypsometrically were in close agreement in most cases. The differences averaged less then 5 per cent. At levels below 10,000 meters the altitudes obtained hypsometrically averaged slightly less than those determined from the 2-theodolite readings and slightly greater at altitudes above 10,000 meters.

The 2-theodolite altitudes were corrected for the curvature of the earth's surface, which correction is additive and amounts to approximately 100 meters when the horizontal distance of the balloon is 35,000 meters and to 1,000 meters when this distance is around 113,000 meters. In some cases the balloon was observed to a horizontal distance of 120,000 meters, the curvature correction for that distance being 1,130 meters.

It will be noted from Figure 1 that practically all of the instruments landed within 200 kilometers of the station and none was found to the westward. The maximum distance from which an instrument was returned was 450
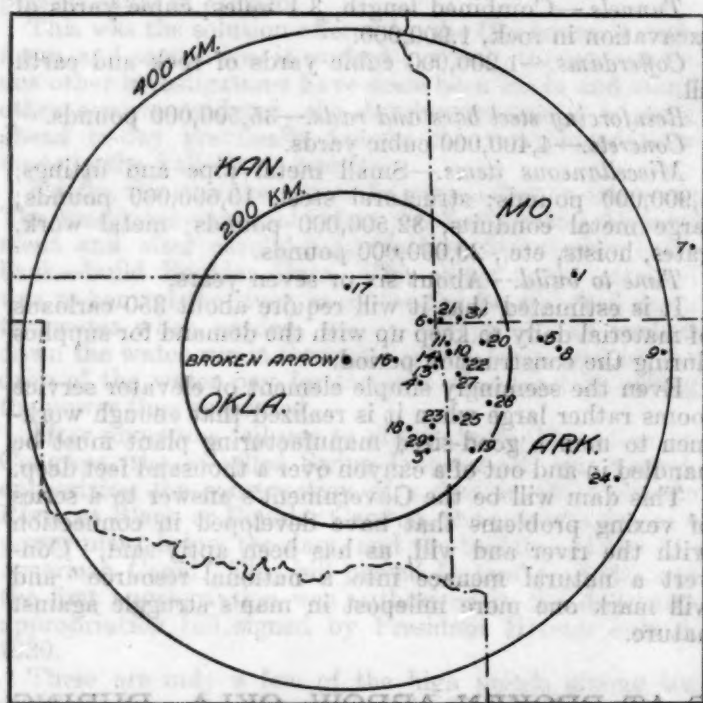
FIGURE 1.—Landing places (with dates) of meteorographs released from Broken Arrow, Okla., during December, 1929

kilometers. This one was released on the 7th and encountered exceptionally strong winds. The balloon was lost to view at 13,200 meters, at which elevation the wind was 60 meters per second from the west-southwest. It was apparently stronger at still greater heights. The weather map of that date indicates an interesting relation between this strong wind and the exceedingly rapid movement of a low-pressure area centered to the northeast of Broken Arrow, accompanied by a rather steep NW.-SE. surface temperature gradient in its rear. Twenty-four hours later this low was centered 2,000 kilometers to the northeast.

The highest elevation reached during the month was 22,921 meters on the 25th. In 17 cases the maximum heights exceeded 15 kilometers; in 6 of these cases the balloons were of the largest size used, i. e., between 91 and 107 centimeters diameter, whereas, with the exception of 2 cases, all of the other balloons were smaller, i. e.,

76 centimeters diameter. In the two cases referred to above the heights reached were more than 13 kilometers. It is therefore evident that the larger balloons proved to be the best for reaching high altitudes.

TEMPERATURE

The lowest temperature recorded during the series was −80.8° C. at 15,191 meters on the 13th. At that altitude the pressure record was obliterated, but the temperature trace shows a further fall to −81.7° C. at apparently 1 kilometer higher. This is the lowest temperature ever recorded on this continent, the previous record being −79.4° C. at 14.8 kilometers at St. Louis, Mo., on January 25, 1905.[1] The low mark of −81.7° C. seems to be confirmed by the observation of the following day (14th), when −77.0° C. was recorded at 16,142 meters. The weather maps of those two days show practically the entire country to have been dominated by large high-pressure areas, with centers over the southern plateau and South Atlantic States, the Canadian Northwest, and and Canadian Maritime Provinces, low-pressure areas being conspicuously absent.

Likewise, the map of January 25, 1905, shows St. Louis to have been close to the center of an exceptionally strong high-pressure area (31.1 inches). It is also found that on the day when the minimum temperature of −78.3° C. at 17,467 meters on October 9, 1927, was recorded during the sounding-balloon series at Groesbeck, Tex. (2), the country was covered by a very extensive high-pressure area.

It seems probable that these very low temperatures in the stratosphere are associated with the cold currents of "equatorial fronts."[2] Unfortunately upper air wind observations were impossible on these days because of cloud conditions over Broken Arrow, the sky being practically covered with stratus moving from the southwest.

The following are some of the significant features of the tropopause obtained for the more recent monthly series of sounding-balloon observations made in this country:

	Date	Mean height of tropopause	Mean temperature of tropopause	Maximum height of tropopause observed	Minimum height of tropopause observed	Range in height of tropopause observed
		Meters	*° C.*	*Meters*	*Meters*	*Meters*
Br	Dec. 1929	10,083	−54.0	12,212	7,728	4,484
Groesbeck, Tex. (2)	Oct. 1927	14,823	−65.5	17,467	11,695	5,772
Royal Center, Ind. (3)	May 1926	12,011	−58.4	18,840	8,878	6,962

The variations found between these stations are very probably the result of both a geographical and seasonal effect.

The altitude and temperature of the tropopause, for the individual observations with the corresponding dates are shown, together with the mean temperature curve, in Figure 2. The usual inverse relationship between temperature and height of the tropopause will be noted.

In Table 1 may be seen the progressive rise and fall of the tropopause during the latter part of the month, when observations of the stratosphere were obtained on several

[1] Annals Harvard College Observatory, vol. 68, pt. 1.
[2] The expression "equatorial front" is used by Willett in Bulletin National Research Council No. 79, Dynamic Meteorology, p. 229, as the antithesis, in a much modified degree, of the well-known expression "polar front."—ED.

consecutive days. It will be noted that a progressive decrease in height occurs from the 19th to the 21st; then an increase in height to the 25th, followed by another general decrease.

The direct relationship usually found between the sea-level pressure and the height of the tropopause was decidedly abnormal. During the latter part of the month, when the tropopause was low, the sea-level pressure was in general above normal, the maximum departure, +0.386 inch, occurring on the same day (21st) that the lowest tropopause was recorded. Likewise, on the 25th, when the highest tropopause was recorded, the sea-level pressure was 0.078 inch *below* normal. In this connection it is noted that there was no apparent connection between the height of the tropopause and the sea-level pressure found at Groesbeck in the series of October, 1927 (2). It would seem that this direct relationship occurs only in the higher latitudes.

In Figure 3 are shown the individual temperature-altitude curves. The surface temperature is indicated at the bottom of each curve and the temperature at the maximum altitude at the top. The wind directions whenever observed are indicated adjacent to the corresponding curves for the standard levels. Attention is invited to the curves for the 7th, 20th, 22d, and 27th, where a south wind component occurs, together with a relatively large decrease of temperature, *within* the stratosphere. This, it appears, is associated with the "equatorial front."

In general when the tropopause is high the lower part of the stratosphere is characterized by a relatively large inversion. This, of course, tends to equalize the temperature in the higher levels of the stratosphere.

The maximum average lapse rate was 0.77° C./100 meters and occurred between 6 and 7 kilometers. (See Fig. 2.) At the Groesbeck (2) this value was 0.79° C./100 meters, and at Royal Center (3), 0.71° C./100 meters. At both of the latter stations, however, this maximum average lapse rate occurred at a slightly greater altitude, viz, between 7 and 8 kilometers.

In Figure 4 are shown the free-air isotherms for the month with the dates indicated across the top. The average height of the tropopause at 10 kilometers is well brought out in this chart. The pronounced isothermal conditions in the stratosphere during the last decade of the month, when most of the higher observations were obtained, are clearly evident.

WIND

Figure 5 shows the mean wind velocity and direction curves for the month. The mean velocities and mean directions were determined independently of each other. It will be noted that the mean velocity reaches a maximum (37.5 m. p. s.) at 11 kilometers, i. e., 1 kilometer above the mean height of the tropopause. Above this height the average velocity decreases at a somewhat lower rate than that at which it increased in the lower levels which indicates a still lower value at altitudes above 21 kilometers.

The mean wind direction veers from south of west below 1,200 meters to north of west, above, up to 21 kilometers, where it is west.
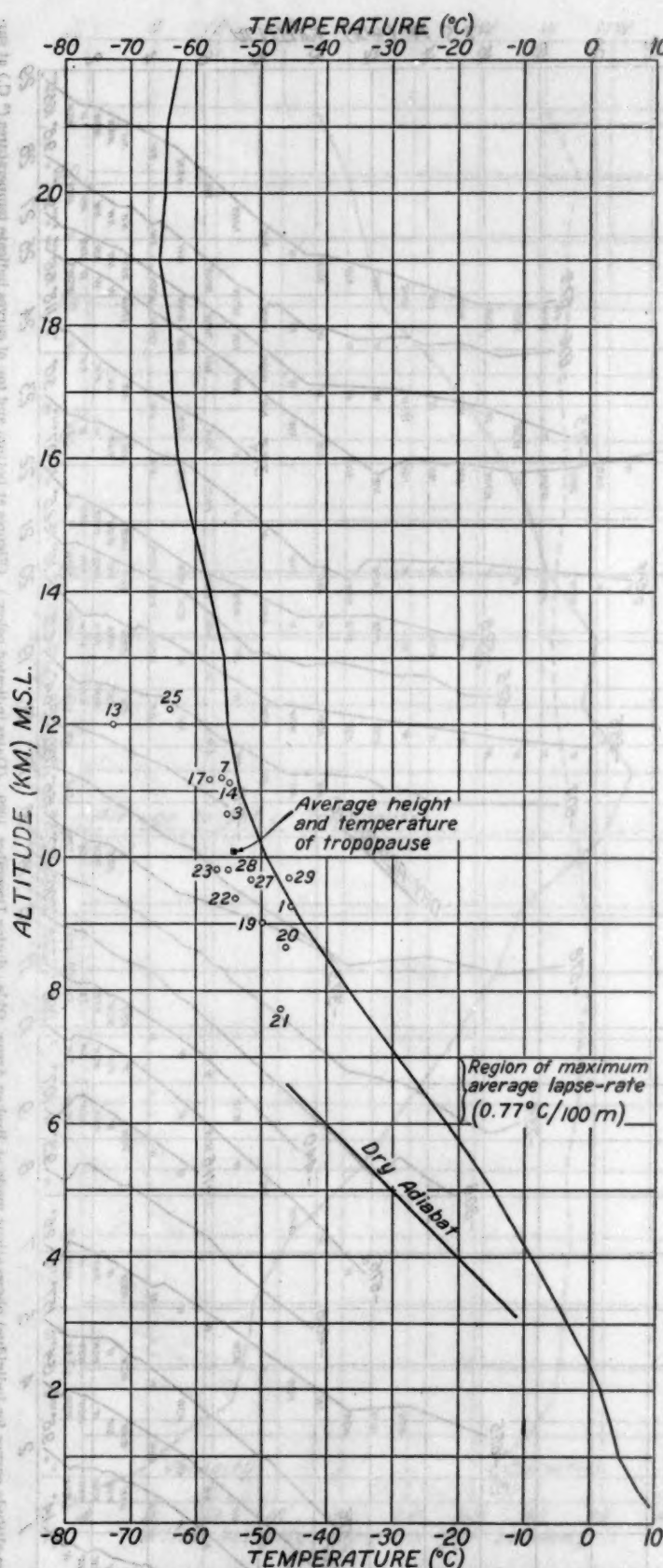
FIGURE 2.—Mean temperature curve (° C.) for December, 1929, Broken Arrow, Okla. (Circles indicate height and temperature of tropopause with corresponding dates)

ALTITUDE (Km.) M.S.L.

DRY ADIABATIC

ALTITUDE (Km.) M.S.L.

Figure 3.—Temperature-altitude curves for individual observations made at Broken Arrow, Okla., during December, 1929. (Dates indicated below.) (Figures at bottom and top of curves indicate temperatures (° C.) at surface and at maximum altitudes; abscissa value of each square corresponds to 20° C. of temperature)

ALTITUDE (Km.) M.S.L.

ALTITUDE (Km.) M.S.L.

Figure 4.—Free-air isotherms (° C.) observed at Broken Arrow, Okla., during December, 1929. (Broken lines drawn between missing days with observations) (Dates indicated at top)

The individual wind velocity curves are shown in Figure 6. The general increase in velocity from the ground to the tropopause is evident and also the decrease within the stratosphere.

Figure 7 shows the wind-direction curves for each observation. The rapid shift to northwesterly between the surface and 2 kilometers is clearly indicated. In no case was a shift to easterly found at the highest levels as at Groesbeck in October, 1927 (2). However, it will be noted that in three cases (3d, 10th, and 29th) the direction at the upper extremities of the curves reaching to high altitudes (above 18 kilometers) veers toward the north. This characteristic is very similar to the curves for Groesbeck (2), where the veering continued past north into east. It seems very probable, therefore, that at somewhat greater heights the upper easterly winds would have been observed at Broken Arrow.

RELATIVE HUMIDITY

Figure 8 shows the mean relative humidity for the month. However, on account of the increasing lag of the hair hygrometric element at temperatures below −15° C., the mean humidity values must be accepted with reservation above 5 kilometers.

For references to previous sounding-balloon series made in this country see MONTHLY WEATHER REVIEW, June, 1929, pages 231–246, and July, 1927, page 302.

TABLE 1.—*Summary of sounding-balloon observations made at Broken Arrow, Okla., during December, 1929*

Date	Time of release, 90th mer.	Stratosphere		Maximum height reached, M. S. L.	Minimum temperature recorded	Theodolite observations		Meteorograph found	
		Height of base, M. S. L.	Temperature at base			2-theodolite	1-theodolite	Distance from station	Direction from station
		M.	*° C.*	*M.*	*° C.*	*Min.*	*Min.*	*Km.*	
1	4:23 p	9,272	−45.4	12,327	−52.7	4	16	300	ENE.
2	4:24 p			13,175		60		(¹)	
3	4:04 p	10,639	−55.0	15,957	−64.0	49	82	145	SE.
4	4:21 p			² 19,600	−54.1	72	78	84	SE.
5	4:07 p			10,759	−57.6	21	28	250	E.
6	4:13 p					5		110	ENE.
7	4:22 p	11,206	−55.9	16,181	−55.5	53	55	450	ENE.
8	3:39 p			9,900	−46.8	16	22	270	E.
9	3:59 p			5,783	−11.6	10	21	385	E.
10	3:58 p			² 20,300	−67.6	80	85	137	E.
11	4:17 p			9,402	−44.0	20	30	127	E.
12	4:20 p					0	15	(¹)	
13	4:19 p	12,000	−72.5	15,191	−81.7	2	5	110	E.
14	4:25 p	11,112	−55.2	17,304	−77.0	0	1	110	E.
15	4:03 p					0	1	(¹)	
16	4:12 p			10,764	−37.3	5	14	63	E.
17	7:27 a	11,072	−57.8	18,962	−60.7	0	4	85	N.
17	4:21 p					1		(¹)	
18	7:52 a					3		(¹)	
18	4:45 p			6,874	−42.0	0	5	120	SE.
19	7:30 a					0		(¹)	
19	4:10 p	8,999	−50.1	18,704	−60.7	48	51	185	SE.
20	4:01 p	8,652	−46.2	20,355	−60.9	³ 83		145	ESE.
21	4:26 p	7,728	−47.1	16,334	−62.5	21		125	ENE.
22	3:32 p	9,386	−54.1	17,790	−62.8	53	66	170	E.
23	4:12 p	9,820	−56.8	21,289	−61.4	78	86	125	SE.
24	4:04 p			² 13,070	−37.3	40	50	365	ESE.
25	3:49 p	12,212	−63.8	22,921	−63.8	90		150	ESE.
26	4:04 p			7,420		27		(¹)	
27	4:21 p	9,660	−51.5	19,078	−71.3	69		160	E.
28	4:22	9,807	−53.0	18,519	−62.3	46	56	190	ESE.
29	3:44 p	9,686	−45.8	18,550	−64.1	74	83	135	SE.
30	4:08 p			15,611		65	73	(¹)	
31	4:10 p			¹ 5,183	(⁴)	21	23	160	NE.

¹ Not found.   ² Maximum altitude from 2-theodolite observation.
³ In the two theodolite observation of the 20th, the balloon was observed until its horizontal distance from the place of observation was 122 km., at which time the balloon had reached an altitude of 18 kms. and had been in the air 83 minutes. So far as is known, this is the greatest horizontal distance to which a balloon has ever been observed by two theodolites.
⁴ Record sheet lost.
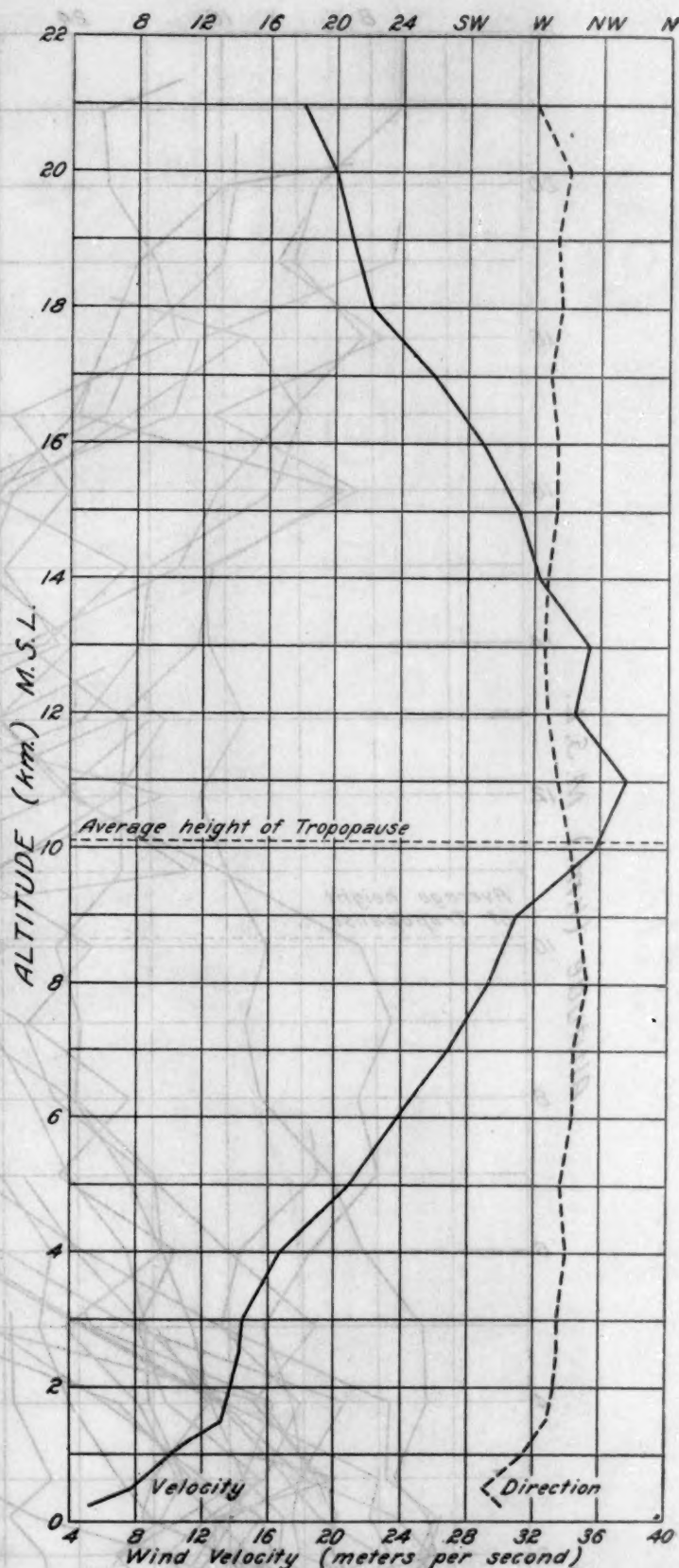
FIGURE 5.—Mean wind velocity (m.p.s.) and direction curves observed at Broken Arrow, Okla., during December, 1929
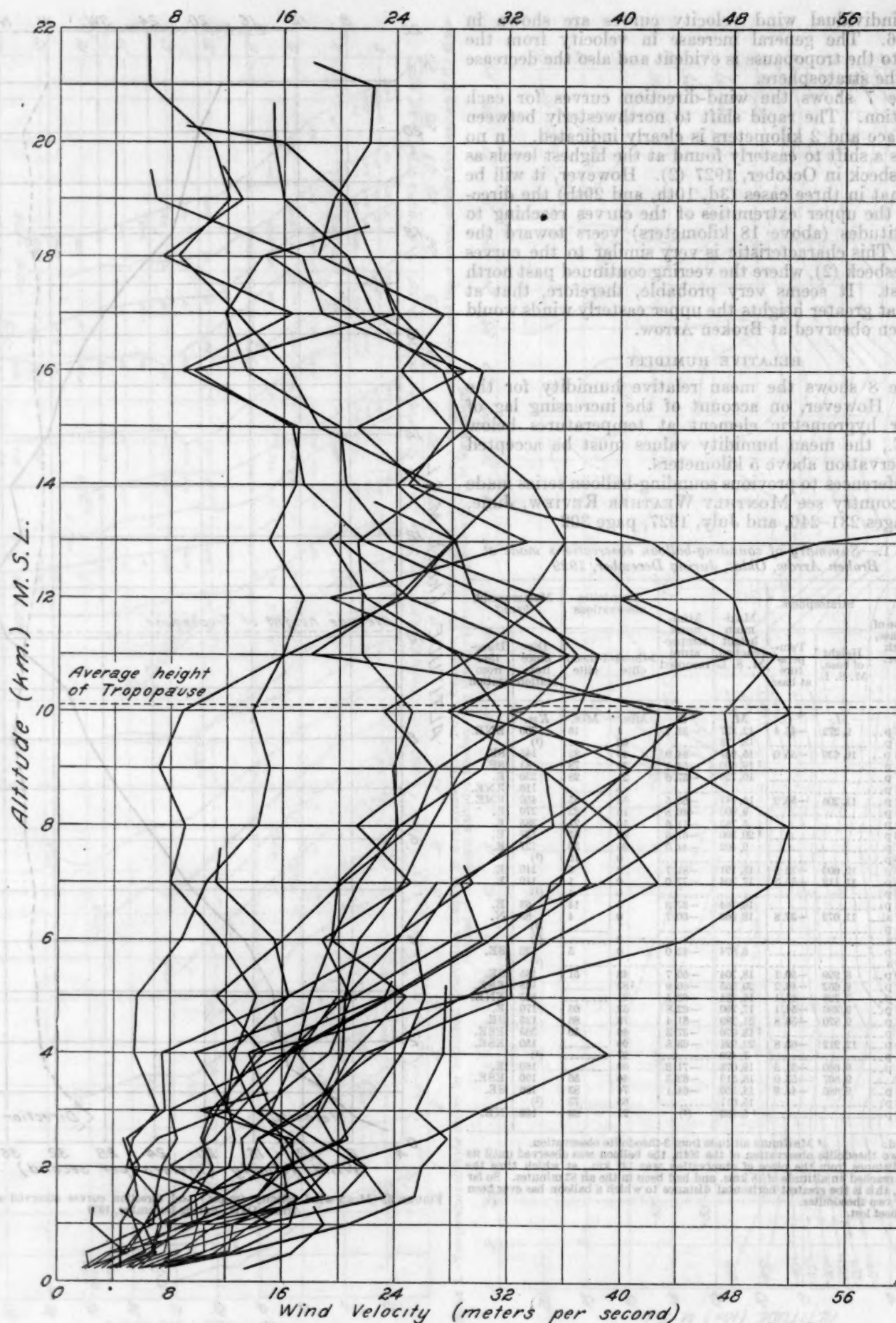
FIGURE 6.—Wind-velocity curves for individual observations made at Broken Arrow, Okla., during December, 1929
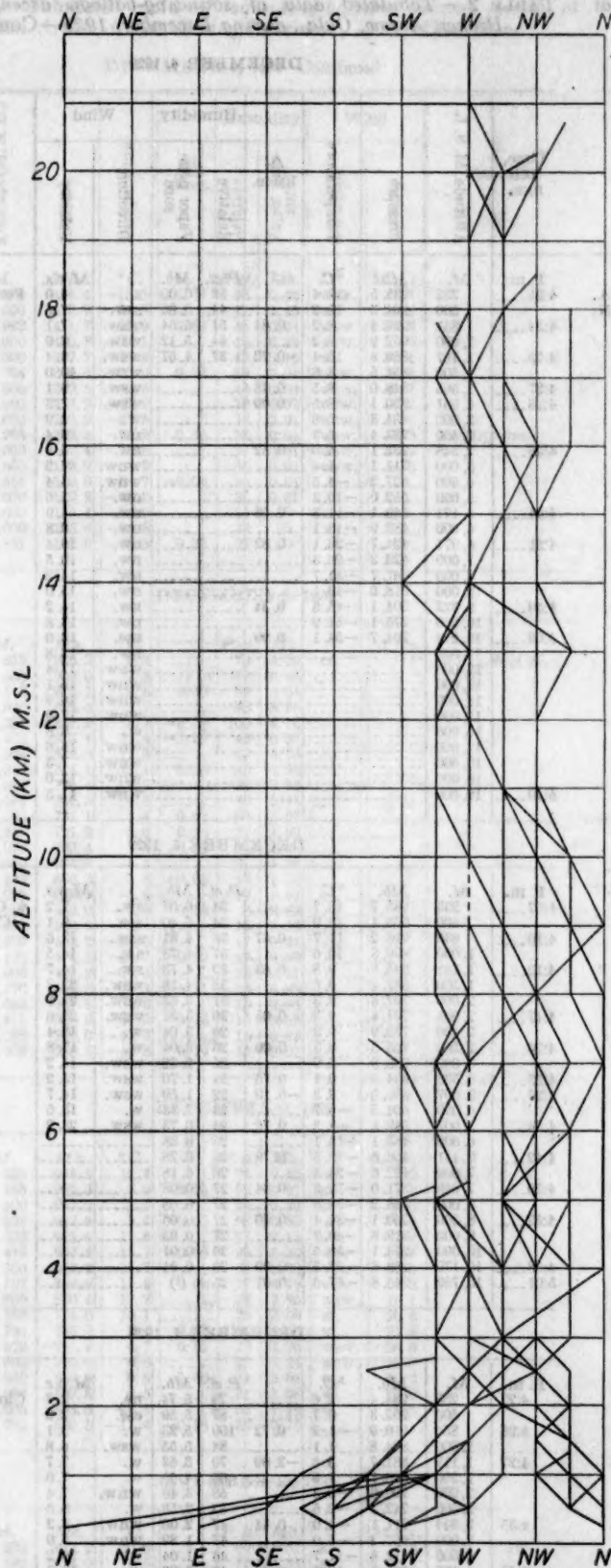
FIGURE 7.—Wind-direction curves for individual observations made at Broken Arrow, Okla., during December, 1929
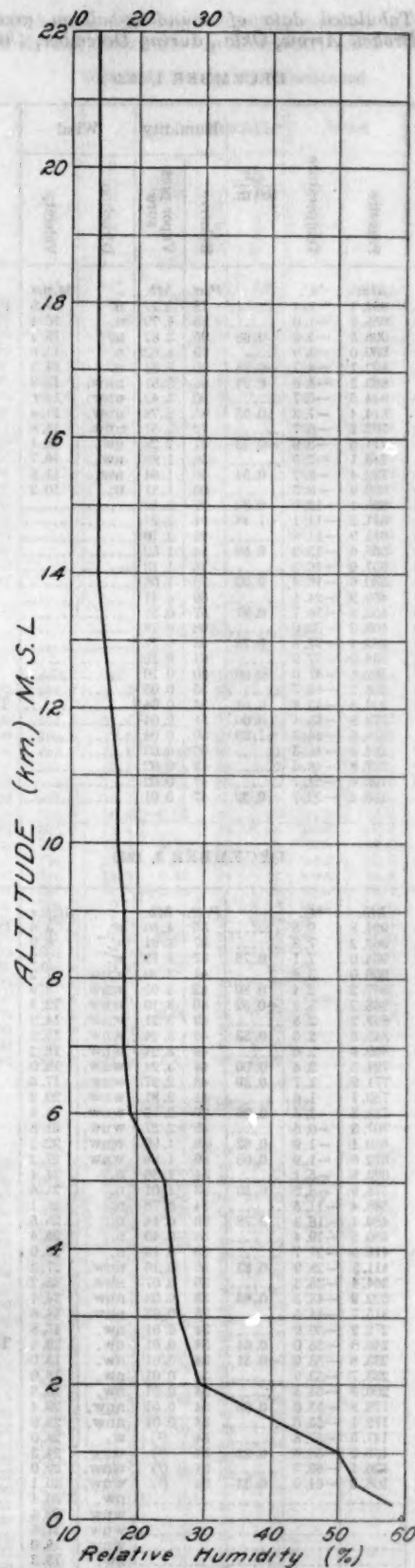
FIGURE 8.—Mean relative humidity curve for December, 1929, Broken Arrow, Okla.

TABLE 2.—Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929

DECEMBER 1, 1929

Time 90th mer.	Altitude, M.S.L.	Pressure	Temperature	Δt/100 m.	Humidity Relative	Humidity Vapor pressure	Wind Direction	Wind Velocity	Remarks
P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
4:23	233	991.1	1.4		78	5.27	n.	7.6	1 Ci. Cu. W.; 5 A. Cu., W.; 3 St., N.
	500	958.6	-1.0		85	4.79	n.	10.4	
4:27	943	906.5	-5.0	0.68	96	3.87	n.	15.4	
	1,000	900.0	-4.9		89	3.62	n.	15.6	
4:28	1,065	892.7	-4.7	-0.25	80	3.31	n.	14.3	
4:29	1,327	863.3	-4.8	0.04	93	3.81	nnw.	13.3	
4:31	1,500	844.5	-5.7	0.55	90	3.42	nnw.	11.8	
	1,785	814.4	-7.3		84	2.78	nnw.	11.8	
	2,000	792.2	-6.7	-0.33	72	2.51	nnw.	11.4	
4:34	2,205	771.6	-5.9		61	2.28	nw.	14.8	
	2,500	743.1	-7.5	0.54	88	1.89	nw.	18.1	
4:36	2,720	722.4	-8.7		56	1.64	nw.	16.7	
	3,000	696.9	-9.5		66	1.81	nw.	11.8	
4:42	3,825	626.1	-12.0	0.30	97	2.12	w.	10.2	
4:43	3,886	621.2	-11.1	-1.48	94	2.24			
	4,000	611.9	-11.8		94	2.10			
4:46	4,602	565.6	-15.3	0.59	94	1.52			
	5,000	537.0	-16.2		76	1.13			
4:49	5,084	530.6	-16.4	0.23	72	1.06			
	6,000	469.9	-24.4		60	0.41			
4:55	6,269	452.3	-26.7	0.87	57	0.31			
	7,000	408.3	-32.0		62	0.19			
5:02	7,816	363.4	-37.9	0.72	68	0.11			
	8,000	354.0	-37.9		61	0.10			
5:03	8,039	352.1	-37.9	0.00	60	0.10			
	9,000	306.2	-43.7		55	0.05			
5:07	9,272	294.5	-45.4		54	0.04			
5:09	9,604	279.8	-45.4	0.61	51	0.04			
5:10	9,689	276.6	-44.3	0.00	50	0.04			Tropopause.
	10,000	264.3	-45.3	-1.29	50	0.03			
	11,000	227.8	-48.5		49	0.02			
	12,000	195.6	-51.7		47	0.02			
5:23	12,327	186.3	-52.7	0.32	47	0.01			

DECEMBER 3, 1929

Time	Altitude	Pressure	Temperature	Δt/100 m.	Rel.	Vapor	Direction	Velocity	Remarks
P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
4:04	233	994.8	9.8		36	4.36	w.	3.6	Cloudless.
	500	963.2	7.8		37	3.91	w.	6.9	
	586	953.0	7.1	0.76	37	3.73	w.	7.2	
4:09	1,000	906.0	3.8		41	3.29	wnw.	7.2	
4:10	1,171	887.2	2.4	0.80	42	3.05	wnw.	8.9	
	1,345	868.2	3.3	-0.52	40	3.10	wnw.	12.2	
	1,500	852.2	2.8		43	3.21	wnw.	14.2	
4:11	1,560	845.6	2.6	0.33	44	3.24	wnw.	15.2	
	2,000	800.9	2.6		44	3.24	wnw.	16.2	
4:14	2,063	794.5	2.6	0.00	44	3.24	wnw.	16.0	
4:15	2,296	771.9	1.7	0.39	43	2.97	wnw.	17.6	
	2,500	752.7	1.6		41	2.81	wnw.	20.2	
4:17	2,656	738.3	1.5	0.06	40	2.72	wnw.	21.4	
	3,000	707.3	-0.6		39	2.27	wnw.	21.8	
4:19	3,208	689.1	-1.9	0.62	38	1.99	wnw.	22.2	
4:20	3,403	672.6	-1.9	0.00	36	1.88	wnw.	22.2	
	4,000	623.6	-5.1		34	1.36	n.	24.4	
4:25	4,582	578.9	-8.2	0.53	33	1.01	n.	24.8	
	5,000	548.4	-11.5		34	0.78	n.	26.1	
4:31	5,870	489.1	-18.3	0.78	36	0.44	n.	25.5	
	6,000	480.5	-19.4		36	0.40	n.	25.4	
	7,000	419.5	-27.7		36	0.18	n.	28.0	
4:36	7,141	411.3	-28.9	0.83	36	0.16	nnw.	27.3	
	8,000	364.4	-36.3		35	0.07	nnw.	35.2	
4:43	8,847	322.9	-43.5	0.86	35	0.03	nnw.	34.4	
	9,000	315.7	-44.5		35	0.03	nnw.	34.6	
	10,000	272.2	-50.9		34	0.01	nw.	45.8	
4:50	10,639	246.8	-55.0	0.64	34	0.01	nw.	39.4	Tropopause.
4:51	10,998	233.8	-53.9	-0.31	34	0.01	nw.	18.0	
	11,000	233.7	-53.9		34	0.01	nw.	18.0	
	12,000	200.9	-54.5		34	0.01	nw.	23.8	
4:56	12,721	179.8	-55.0	0.06	34	0.01	nw.	29.4	
	13,000	172.1	-55.6		34	0.01	nnw.	28.0	
	14,000	147.5	-57.8		34	(1)	nnw.	24.0	
5:02	14,372	139.2	-58.6	0.22	34	(1)	w.	24.0	
	15,000	126.1	-60.7		34	(1)	wnw.	24.3	
5:08	15,957	108.2	-64.0	0.34	34	(1)	wnw.	29.0	
	16,000						wnw.	30.1	
	17,000						nw.	30.4	
	18,000						w.	22.5	
	19,000						wnw.	21.6	
	20,000						wnw.	16.0	
5:26	20,690						nw.	15.3	
							nnw.	15.2	

Less than 0.01 mb.

DECEMBER 4, 1929

TABLE 2.—Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929—Continued

Time, 90th mer.	Altitude, M.S.L.	Pressure	Temperature	Δt/100 m.	Relative	Vapor pressure	Direction	Velocity	Remarks
P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
4:21	233	995.5	13.4		39	6.00	s.	4.0	Few Ci., WNW.
	500	964.3	11.2		44	5.85	ssw.	7.6	
4:24	851	924.4	8.2	0.84	51	5.54	wsw.	7.1	
	1,000	907.9	9.2		44	5.12	wsw.	8.0	
4:25	1,167	889.8	10.4	-0.70	37	4.67	wsw.	9.4	
	1,500	854.5	8.8				wsw.	10.0	
4:27	1,565	848.0	8.5				wsw.	9.1	
4:28	1,681	836.1	8.5	0.48			wsw.	7.3	
	2,000	804.3	6.8	0.00			w.	4.9	
	2,500	753.4	4.3				nw.	5.4	
4:32	2,548	752.1	4.0	0.52			nw.	5.4	
	3,000	711.1	1.4				wnw.	7.2	
	4,000	627.2	-4.5				wnw.	5.4	
	5,000	552.0	-10.3				nw.	5.6	
4:44	5,171	540.1	-11.3	0.58			nw.	5.9	
	6,000	483.9	-18.1				nw.	8.8	
4:51	6,971	424.7	-26.1	0.82			nw.	10.4	
	7,000	423.2	-26.3				nw.	10.5	
	8,000	367.7	-34.7				nw.	14.2	
	9,000	318.6	-43.1				nw.	15.0	
4:59	9,323	304.1	-45.8	0.84			nw.	14.2	
	10,000	275.1	-51.9				nw.	13.8	
5:02	10,248	264.7	-54.1	0.90			nw.	13.0	
	11,000						nw.	13.0	
	12,000						nw.	15.8	
	13,000						wnw.	17.4	
	14,000						wnw.	15.1	
	15,000						wnw.	16.9	
	16,000						wnw.	17.0	
	17,000						w.	8.8	
	18,000						wnw.	16.6	
	19,000						wnw.	7.3	
5:40	19,600						wnw.	13.0	
							wnw.	11.5	

DECEMBER 5, 1929

Time	Altitude	Pressure	Temperature	Δt/100 m.	Rel.	Vapor	Direction	Velocity	Remarks
P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
4:07	233	985.7	15.7		34	6.07	sw.	7.2	6 Ci., W.; 2 Ci. Cu., W.
	500	955.1	13.9		34	5.40	ssw.	8.1	
	830	918.2	11.7	0.67	35	4.81	ssw.	13.6	
4:10	1,000	909.8	10.6		37	4.73	sw.	14.5	
4:12	1,131	885.8	9.8	0.63	39	4.73	sw.	14.7	
	1,500	847.4	9.6		35	4.18	wsw.	23.3	
	2,000	797.8	9.3		31	3.63	wsw.	21.8	
4:17	2,065	791.4	9.3	0.05	30	3.51	wsw.	21.6	
	2,500	750.9	9.3		26	3.04	w.	18.4	
4:20	2,560	745.5	9.3	0.00	26	3.04	w.	17.8	
	3,000	706.8	5.9		25	2.32	w.	15.2	
4:25	3,503	664.5	2.1	0.76	24	1.70	wsw.	15.2	
4:26	3,607	656.0	2.3	-0.19	22	1.59	wsw.	14.7	
	4,000	624.5	-0.7		23	1.33	w.	13.6	
4:34	5,005	549.8	-8.3	0.76	24	0.73	wsw.	23.2	
4:42	6,431	456.6	-16.1		25	0.38			
	7,000	422.6	-19.5	0.79	25	0.28			
4:50	7,949	371.0	-24.3		26	0.18			
	8,000	368.2	-32.3	0.84	27	0.08			
4:52	8,366	350.1	-32.6	0.50	27	0.08			
	9,000	319.6	-34.4		27	0.06			
	10,000	276.1	-40.7		27	0.03			
4:58	10,179	268.6	-50.5	0.99	26	0.01			
5:01	10,759	245.8	-52.3	0.91	26	0.01			
			-57.6		25	(1)			

DECEMBER 7, 1929

Time	Altitude	Pressure	Temperature	Δt/100 m.	Rel.	Vapor	Direction	Velocity	Remarks
P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
4:23	233	984.4	2.6		78	5.74	ne.	2.2	Cloudless.
	500	952.3	0.7		87	5.59	ese.	2.0	
4:26	856	910.9	-1.9	0.72	100	5.23	w.	5.1	
	1,000	894.8	1.1		84	5.55	wsw.	6.8	
4:27	1,119	881.7	3.6	-2.09	70	5.53	w.	7.7	
	1,500	840.7	1.9		65	4.55	w.	7.0	
	2,000	790.0	-0.3		58	3.46	wnw.	7.4	
	2,500	742.4	-2.5		52	2.58	w.	8.5	
4:35	2,844	711.1	-4.0	0.44	47	2.06	wnw.	8.2	
	3,000	697.2	-5.0		47	1.89	wnw.	8.0	
	4,000	612.8	-11.7		46	1.04	w.	16.2	
4:42	4,130	602.6	-12.6		46	0.96	w.	18.2	
4:43	4,555	570.0	-11.4	-0.28	48	1.11	w.	23.8	
	5,000	537.8	-14.3	0.67	45	0.80	w.	23.4	

[1] Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929*—Continued

DECEMBER 7, 1929—Continued

Time, 90th mer.	Altitude (M. S. L.)	Pressure	Temperature	Δt/100 m.	Humidity Relative	Humidity Vapor pressure	Wind Direction	Wind Velocity	Remarks
P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
4:48	5,636	494.4	-18.5	0.66	40	0.48	wsw.	28.4	
	6,000	470.9	-20.8		41	0.40	w.	30.2	
4:52	6,982	411.7	-27.0	0.63	45	0.24	wsw.	28.6	
	7,000	410.8	-27.1		45	0.23	wsw.	28.6	
	8,000	357.3	-34.3		42	0.10	w.	34.1	
4:58	8,784	319.6	-39.9	0.72	40	0.05	wsw.	38.8	
	9,000	309.5	-41.3		40	0.04	wsw.	40.7	
	10,000	267.2	-47.9		39	0.02	wsw.	35.2	
	11,000	229.9	-54.5		38	0.01	wsw.	48.1	
5:07	11,206	222.5	-55.9	0.66	38	0.01	wsw.	49.9	Tropopause.
	12,000	197.4	-55.5		37	0.01	wsw.	39.9	
	13,000	169.0	-54.9		36	0.01	wsw.	54.0	
5:16	13,356	159.9	-54.7	-0.06	35	0.01			
	14,000	149.8	-57.2		35	0.01			
	15,000	123.4	-61.0		34	(¹)			
	16,000	105.6	-64.8		33	(¹)			
5:37	16,181	102.6	-65.5	0.38	33	(¹)			

DECEMBER 8, 1929

P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
3:39	233	986.2	9.3		70	8.20	se.	5.4	10 Ci., WNW.
	500	955.0	7.8		80	8.46			
3:42	873	912.7	5.6	0.58	95	8.64			
	1,000	898.6	5.7		98	8.98			
3:43	1,067	891.2	5.7	-0.05	100	9.16			
3:45	1,425	853.4	11.4	-1.59	45	6.07			
	1,500	845.8	11.3		43	5.76			
3:47	1,819	814.1	11.1	0.08	35	4.62			
	2,000	796.4	9.9		32	3.90			
	2,500	749.5	6.7		25	2.45			
3:50	2,705	731.1	5.4	0.64	22	1.97			
3:51	2,817	721.2	5.0	0.36	22	1.92			
3:52	2,978	707.4	3.6	0.87	21	1.66			
	3,000	705.5	3.6		21	1.66			
3:53	3,233	685.3	3.8	-0.08	19	1.52			
	4,000	622.9	-1.4		19	1.03			
4:01	4,801	563.0	-6.9	0.68	8	0.62			
	5,000	548.9	-8.1		18	0.56			
	6,000	482.2	-14.0		17	0.31			
4:06	6,126	474.5	-14.7	0.59	17	0.29			
	7,000	422.2	-24.4		16	0.11			
4:11	7,170	412.5	-26.3	1.11	16	0.09			
	8,000	367.3	-32.6		15	0.04			
4:16	8,611	336.9	-37.3	0.76	15	0.03			
	9,000	319.0	-40.2		15	0.02			
4:20	9,900	280.2	-46.8	0.74	15	0.01			

DECEMBER 9, 1929

P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
3:59	233	988.5	10.7		74	9.52	n.	2.2	10 Ci. St., W.
4:00	465	961.3	8.5	0.95	92	10.21	ne.	2.8	
	500	957.2	8.5		93	10.32	e.	3.8	
4:01	675	937.3	8.4	0.05	98	10.80	ssw.	7.6	
	1,000	901.4	11.6		67	9.15	sw.	12.5	
4:04	1,419	857.5	15.7	-0.98	28	5.00	wsw.	16.4	
	1,500	849.3	15.7		28	5.00	wsw.	16.4	
4:05	1,597	839.9	15.6	0.06	27	4.79	wsw.	16.2	
	2,000	800.4	13.2		26	3.95	wsw.	16.1	
	2,500	754.0	10.1		25	3.09	w.	20.6	
4:10	2,734	733.2	8.7	0.61	24	2.70	w.	21.6	
4:13	2,978	711.9	6.7	0.82	23	2.26	wsw.	20.0	
	3,000	710.0	6.6		23	2.24	wsw.	20.0	
4:16	3,960	630.9	0.8	0.60	31	2.01	w.	16.6	
	4,000	627.8	0.5		31	1.96	w.	17.0	
	5,000	553.5	-6.3		32	1.16	w.	19.8	
4:23	5,783	500.6	-11.6	0.68	33	0.75			

DECEMBER 10, 1929

P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
3:58	233	988.2	20.6		60	14.57	s.	5.8	4 Ci., WSW.
	500	958.0	18.5		75	15.98	s.	12.2	
4:01	878	916.8	15.6	0.78	96	17.02	ssw.	11.3	
	1,000	903.7	15.1		90	15.45	ssw.	12.5	
4:02	1,005	903.2	15.1	0.39	90	15.45	ssw.	12.6	
4:03	1,106	892.3	15.2	-0.10	55	9.50	sw.	15.2	
4:04	1,294	872.8	17.0	-0.96	40	7.75	sw.	18.0	
	1,500	852.1	16.6		37	6.99	sw.	18.6	
4:07	1,965	806.6	15.6	0.21	30	5.32	wsw.	16.9	
	2,000	803.3	15.4		30	5.25	wsw.	16.8	
	2,500	757.0	12.9		29	4.32	wsw.	15.8	
	3,000	713.2	10.3		28	3.51	w.	12.0	
4:12	3,158	699.8	9.5	0.51	28	3.32	w.	11.5	
	4,000	631.5	2.9		25	1.88	w.	12.6	
	5,000	558.1	-5.0		22	0.89	w.	14.1	

TABLE 2.—*Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929*—Continued

DECEMBER 10, 1929—Continued

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	Δt/100 m.	Humidity Relative	Humidity Vapor pressure	Wind Direction	Wind Velocity	Remarks
P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
4:22	5,430	528.7	-8.4	0.79	20	0.60	wsw.	13.8	
	6,000	490.7	-13.4		20	0.39	wsw.	11.6	
	7,000	429.4	-22.3		19	0.16	w.	8.0	
	8,000	374.3	-31.1		19	0.06	nw.	9.0	
	9,000	324.5	-39.9		18	0.02	wnw.	7.2	
4:37	9,486	302.6	-44.2	0.88	18	0.01	wnw.	8.4	
	10,000	280.1	-49.5		18	0.01	w.	8.8	
	11,000	240.1	-59.7		17	(¹)	w.	16.3	
4:45	11,775	212.1	-67.6	1.02	16	(¹)	w.	21.9	
	12,000						w.	24.5	
	13,000						wsw.	28.0	
	14,000						w.	32.0	
	15,000						w.	32.0	
	16,000						w.	28.1	
	17,000						w.	24.1	
	18,000						w.	22.2	
	19,000						w.	20.6	
	20,000						wnw.	15.9	
5:19	20,300						nw.	9.0	

DECEMBER 11, 1929

P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
4:17	233	984.3	22.8		62	17.22	s.	7.6	3 Ci. St., W.; 6 Ci., W.
	500	954.5	21.0		71	17.66	ssw.	11.2	
	1,000	900.8	17.5		87	17.41	ssw.	13.9	
4:21	1,106	889.8	16.8	0.69	90	17.23	sw.	14.5	
4:22	1,235	876.4	16.4	0.31	88	16.42	sw.	15.1	
4:23	1,440	855.3	15.7	0.34	65	11.60	sw.	16.9	
	1,500	849.4	15.7		61	10.88	sw.	17.4	
4:25	1,918	808.6	16.0	-0.06	36	6.55	wsw.	19.0	
	2,000	800.9	15.4		38	6.65	wsw.	19.4	
4:26	2,238	778.6	13.5	0.78	43	6.66	wsw.	19.6	
	2,500	754.7	11.9		36	5.01	wsw.	17.0	
4:28	2,556	748.7	11.5	0.61	34	4.61	wsw.	16.6	
4:29	2,692	737.5	11.7	-0.16	32	4.40	wsw.	16.2	
	3,000	710.7	9.8		31	3.76	wsw.	14.0	
	4,000	629.5	3.5		28	2.20	w.	12.5	
4:37	4,778	571.9	-1.4	0.63	25	1.36	w.	16.0	
	5,000	556.1	-3.0		25	1.19	w.	16.4	
4:41	5,887	496.8	-9.4	0.72	23	0.63	w.	16.4	
	6,000	489.4	-10.5		23	0.58	w.	15.4	
	7,000	429.4	-20.0		24	0.25	wsw.	11.2	
4:47	7,325	411.3	-23.1	0.95	24	0.18	w.	10.9	
	8,000	375.0	-29.9		25	0.10			
	9,000	326.1	-40.0		27	0.04			
4:54	9,402	307.9	-44.0	1.01	28	0.02			

DECEMBER 13, 1929

P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
4:19	233	991.9	20.0		83	19.42	s.	6.7	2 Ci. St., WSW.; 8 St., SSW.
	500	981.7	18.2		92	19.24	ssw.	9.5	
4:22	738	935.3	16.6	0.67	100	18.90	ssw.	11.6	
4:23	994	907.6	16.0	0.23	88	16.01	wsw.	10.0	
	1,000	907.0	16.0		88	16.01	wsw.	10.0	
4:24	1,415	863.8	14.6	0.33	99	15.79			
	1,500	855.1	14.5		90	14.86			[2] Lowest temperature recorded; altitude approximately 16,476 m., M. S. L., based on ascensional rate.
4:25	1,589	846.2	14.4	0.11	85	13.95			
	2,000	805.8	11.4		82	11.05			
	2,500	758.8	7.7		79	8.30			
4:30	2,633	746.8	6.7	0.74	78	7.65			
	3,000	714.1	4.5		54	4.55			
4:32	3,031	711.2	4.3	0.60	52	4.32			
4:35	3,705	654.6	2.0	0.34	40	2.82			
	4,000	631.1	0.2		40	2.48			
4:37	4,313	606.9	-1.8	0.62	39	2.06			
	5,000	556.4	-8.7		43	1.26			
4:41	5,028	554.4	-9.0	1.01	43	1.23			
4:42	5,454	524.9	-11.3	0.54	36	0.84			
	6,000	488.8	-16.4		33	0.49			
4:45	6,032	486.5	-16.7	0.93	33	0.47			
	7,000	427.4	-25.5		32	0.19			
4:52	7,457	401.7	-29.7	0.84	31	0.12			
	8,000	372.3	-34.4		30	0.07			
4:57	8,760	334.3	-41.0	0.87	29	0.03			
	9,000	322.7	-43.2		29	0.03			
	10,000	278.5	-52.2		30	0.01			
5:03	10,371	263.2	-55.6	0.91	30	0.01			
	11,000	239.2	-62.1		30	(¹)			
5:10	12,000	204.1	-72.5	1.04	31	(¹)			Tropopause.
5:13	12,592	185.5	-69.1	-0.57	31	(¹)			
5:15	12,958	174.9	-65.9	-0.87	30	(¹)			
	13,000	173.5	-66.2		30	(¹)			
5:19	13,905	150.3	-73.1	0.76	28	(¹)			
	14,000	148.0	-73.7		28	(¹)			
	15,000	125.2	-79.2		27	(¹)			
5:28	15,191	121.3	-80.8	0.60	27	(¹)			
5:30			-81.7[1]						

¹ Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929*—Continued

DECEMBER 14, 1929

Time 90th mer.	Altitude, M.S.L.	Pressure	Temperature	Δt/100 m.	Humidity Relative	Humidity Vapor pressure	Wind Direction	Wind Velocity	Remarks
P.m.	M.	Mb.	°C.		P.ct.	Mb.	s.	M.p.s.	
4:25	233	993.7	17.2	----	95	18.65	s.	3.1	1 A. St., SW.; 9 St., SSW.
	800	963.0	15.9		95	17.17			
	1,000	908.0	13.5		96	14.86			
4:30	1,278	878.4	12.1	0.49	96	13.56			
	1,500	855.3	11.4		73	9.84			
4:31	1,513	854.1	11.4	0.30	72	9.71			
	2,000	805.7	10.0		65	7.98			
4:34	2,108	795.3	9.7	0.29	63	7.58			
4:35	2,463	762.1	7.4	0.65	60	6.18			
	2,500	758.7	7.3		58	5.93			
4:37	2,891	723.4	5.9	0.35	35	3.25			
	3,000	713.8	5.0		34	2.96			
4:39	3,292	688.5	2.7	0.80	33	2.45			
4:40	3,683	656.2	0.3	0.61	65	4.06			
	4,000	630.9	-1.9		75	3.92			
4:44	4,626	582.9	-6.3	0.70	96	3.47			
4:45	4,847	566.9	-7.6	0.59	84	2.71			
	5,000	555.8	-9.0		79	2.26			
4:47	5,214	540.5	-11.0	0.93	72	1.73			
4:49	5,785	502.1	-12.9	0.33	46	0.93			
4:50	5,925	492.8	-14.2	0.93	47	0.85			
	6,000	488.0	-14.8		46	0.78			
4:51	6,394	463.1	-18.1	0.83	43	0.54			
4:52	6,528	455.1	-18.5	0.30	35	0.42			
4:55	6,957	429.8	-23.4	1.14	26	0.20			
	7,000	427.2	-23.7		26	0.19			
	8,000	372.7	-30.6		32	0.12			
4:58	8,260	359.2	-32.4	0.69	34	0.10			
	9,000	323.7	-38.3		36	0.06			
5:03	9,767	289.8	-44.5	0.80	38	0.03			
	10,000	280.1	-46.4		38	0.02			
	11,000	241.5	-54.3		39	0.01			
5:07	11,112	237.2	-55.2	0.80	39	0.01			Tropopause.
	12,000	207.3	-57.3		35	0.01			
5:11	12,316	197.4	-58.0	0.23	34	(¹)			
5:13	12,523	191.0	-59.1	0.53	33	(¹)			
5:15	12,837	181.8	-58.8	-0.10	33	(¹)			
	13,000	177.2	-59.5		33	(¹)			
5:18	13,556	162.8	-61.8	0.42	31	(¹)			
	14,000	151.7	-65.0		31	(¹)			
5:21	14,212	146.8	-66.5	0.72	31	(¹)			
	15,000	129.2	-71.1		31	(¹)			
5:26	15,144	126.1	-71.9	0.58	31	(¹)			
	16,000	109.6	-76.3		30	(¹)			
5:32	16,142	106.9	-77.0	0.51	30	(¹)			
5:33	16,543	100.3	-76.6	-0.10	30	(¹)			
	17,000	93.1	-74.7		30	(¹)			
5:42	17,324	88.2	-73.4	-0.41	31	(¹)			

DECEMBER 16, 1929

Time 90th mer.	Altitude, M.S.L.	Pressure	Temperature	Δt/100 m.	Humidity Relative	Humidity Vapor pressure	Wind Direction	Wind Velocity	Remarks
P.m.	M.	Mb.	°C.		P.ct.	Mb.	s.	M.p.s.	
4:12	233	985.9	16.6		76	14.36	s.	4.5	4 St. Cu., SSW., at 4:12 p.m., increasing to 9 St. Cu., SSW., by 4:20 p.m.
	500	955.3	14.4		85	13.95	sse.	4.5	
4:17	952	905.3	10.6	0.83	100	12.78	ssw.	4.5	
	1,000	900.1	10.5		97	12.32	ssw.	4.5	
4:18	1,194	879.5	9.9	0.29	85	10.37	ssw.	4.4	
	1,500	847.6	8.0		93	9.98	sw.	5.7	
4:21	1,742	823.2	6.5	0.62	100	9.68	wsw.	6.0	
4:22	1,898	807.6	6.1	0.26	66	6.21	wsw.	5.8	
	2,000	797.6	6.3		60	5.72	wsw.	5.4	
4:23	2,163	782.0	6.5	-0.15	51	4.94	wsw.	5.0	
	2,500	750.5	5.1		44	3.86	ssw.	4.7	
4:25	2,592	741.9	4.7	0.42	42	3.59	wsw.	4.5	
4:27	2,868	717.3	2.7	0.72	46	3.41			
	3,000	705.7	1.8		44	3.06			
4:32	4,003	622.4	-4.8	0.66	32	1.31			
4:36	4,937	552.3	-11.6	0.73	34	0.77			
	5,000	547.7	-11.8		34	0.76			
4:39	5,622	505.2	-13.8	0.32	30	0.56			
	6,000	479.7	-15.2		29	0.48			
	7,000	420.2	-18.7		28	0.33			
	8,000	367.6	-22.4		26	0.22			
4:44	8,430	347.3	-23.9	0.36	25	0.18			
	9,000	321.0	-26.7		25	0.13			
	10,000	280.3	-31.7		24	0.08			
4:49	10,165	273.5	-32.5	0.50	24	0.07			
4:51	10,528	259.9	-35.3	0.77	25	0.05			
4:52	10,764	251.4	-37.3	0.85	24	0.04			

DECEMBER 17, 1929

Time 90th mer.	Altitude, M.S.L.	Pressure	Temperature	Δt/100 m.	Humidity Relative	Humidity Vapor pressure	Wind Direction	Wind Velocity	Remarks
A.m.	M.	Mb.	°C.		P.ct.	Mb.	e.	M.p.s.	
7:27	233	982.2	13.0		98	14.68	e.	2.7	9 St. Cu., Sw.; 10 light haze.
	500	951.5	12.4		95	13.68	se.	4.8	
7:30	924	904.7	11.4	0.23	91	12.27	sse.	2.5	
	1,000	896.2	11.0		92	12.08	sse.	2.4	

¹ Less than 0.01 mb.

DECEMBER 17, 1929—Continued

Time 90th mer.	Altitude (M.S.L.)	Pressure	Temperature	Δt/100 m.	Humidity Relative	Humidity Vapor pressure	Wind Direction	Wind Velocity	Remarks
A.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
7:32	1,399	854.5	9.1	0.49	100	11.56			
	1,500	843.9	8.6		96	10.72			
7:35	1,946	800.0	6.4	0.50	79	7.59			
	2,000	794.3	5.9		80	7.42			
	2,500	747.1	1.9		91	6.37			
7:38	2,702	728.7	0.3	0.80	96	5.99			
	3,000	701.9	-1.3		74	4.06			
7:41	3,391	668.7	-3.4	0.54	46	2.12			
	4,000	618.7	-7.8		44	1.39			
7:47	4,711	564.4	-12.9	0.72	41	0.83			
	5,000	543.7	-14.1		38	0.69			
7:51	5,669	498.1	-17.0	0.43	30	0.42			
	6,000	476.5	-20.7		34	0.33			
7:55	6,656	435.7	-28.0	1.11	41	0.19			
	7,000	415.7	-30.2		42	0.16			
	8,000	361.3	-36.7		45	0.08			
8:01	8,380	342.2	-39.1	0.64	46	0.06			
	9,000	312.9	-43.4		46	0.04			
	10,000	269.9	-50.4		45	0.02			
	11,000	231.9	-57.3		44	0.01			
8:10	11,072	229.3	-57.8	0.69	44	0.01			Tropopause.
	12,000	199.4	-56.8		42	0.01			
	13,000	170.9	-55.8		40	0.01			
	14,000	146.0	-54.7		38	0.01			
8:18	14,019	145.6	-54.7	-0.11	38	0.01			
	15,000	125.1	-56.9		37	0.01			
	16,000	107.3	-59.1		37	(¹)			
8:28	16,706	95.9	-60.7	0.22	36	(¹)			
	17,000	91.8	-60.3		36	(¹)			
	18,000	78.6	-59.0		36	(¹)			
8:38	18,962	67.5	-57.8	-0.13	36	(¹)			

DECEMBER 18, 1929

Time 90th mer.	Altitude (M.S.L.)	Pressure	Temperature	Δt/100 m.	Humidity Relative	Humidity Vapor pressure	Wind Direction	Wind Velocity	Remarks
P.m.	M.	Mb.	°C.		P.ct.	Mb.	n.	M.p.s.	
4:45	233	999.0	-8.4		70	2.11	n.	13.4	6 A. Cu., NW.; 4 St., NNW.
	500	965.0	-10.4				nnw.	16.7	
4:48	903	915.5	-13.4	0.75			nw.	19.1	
	1,000	904.0	-12.9				nw.	18.9	
4:49	1,185	882.3	-12.0	-0.50			nnw.	18.2	
	1,500	846.6	-13.4						
	2,000	792.5	-15.7						
4:53	2,010	791.4	-15.7	0.45					
4:54	2,246	767.2	-16.0	0.13					
	2,500	741.8	-17.3						
	3,000	693.6	-19.9						
4:59	3,249	670.7	-21.2	0.52					
5:00	3,505	647.8	-22.6	0.55					
	4,000	605.5	-24.6						
5:04	4,542	562.0	-26.7	0.40					
	5,000	527.3	-30.3						
5:06	5,071	522.3	-30.9	0.79					
	6,000	457.7	-36.6						
5:12	6,874	403.1	-42.0	0.62					

DECEMBER 19, 1929

Time 90th mer.	Altitude (M.S.L.)	Pressure	Temperature	Δt/100 m.	Humidity Relative	Humidity Vapor pressure	Wind Direction	Wind Velocity	Remarks
P.m.	M.	Mb.	°C.		P.ct.	Mb.	nw.	M.p.s.	
4:10	233	996.5	-6.0		45	1.66	nw.	4.9	Cloudless.
	500	962.9	-8.4		47	1.41	nw.	6.6	
4:14	762	930.9	-10.7	0.89	48	1.18	nw.	6.6	
	1,000	902.2	-13.1		51	1.01	nw.	7.2	
4:18	1,464	848.2	-17.8	1.01	56	0.72	nw.	10.1	
	1,500	844.1	-17.6		55	0.72	nw.	10.4	
4:19	1,646	827.9	-17.0	-0.44	50	0.70	nnw.	12.4	
4:20	1,848	806.1	-16.8	-0.10	44	0.62	nnw.	13.2	
	2,000	789.7	-17.2		47	0.64	nnw.	13.6	
4:21	2,157	773.4	-17.6	0.26	51	0.67	nw.	13.9	
4:23	2,456	743.3	-17.8	0.07	51	0.66	nw.	14.0	
	2,500	738.8	-18.0		51	0.64	nw.	14.3	
	3,000	690.8	-20.1		56	0.58	nw.	18.0	
4:26	3,008	690.2	-20.1	0.42	56	0.58	nw.	18.3	
4:28	3,355	658.6	-20.7	0.17	57	0.56	nw.	21.2	
4:29	3,629	634.5	-20.7	0.00	52	0.51	nw.	20.8	
4:30	3,744	624.5	-21.5	0.70	51	0.46	nw.	24.6	
	4,000	603.3	-21.7		49	0.44	nw.	21.9	
4:35	4,478	565.1	-22.1	0.08	45	0.38	nw.	33.0	
	5,000	526.3	-25.3		43	0.27	nw.	32.2	
4:40	5,624	483.0	-29.1	0.61	40	0.17	nw.	32.5	
	6,000	457.7	-32.4		39	0.12	nw.	32.0	
4:45	6,538	423.4	-37.2	0.89	38	0.07	nw.	31.7	
	7,000	396.8	-39.1		37	0.05	nw.	37.8	
4:49	7,417	374.1	-40.9	0.42	37	0.04	nw.	38.3	
	8,000	343.2	-44.3		37	0.03	nw.	36.0	
4:56	8,999	295.3	-50.1	0.58	37	0.01	nw.	40.6	Tropopause.
5:00	9,993	253.8	-50.1	0.00	36	0.01	nw.	44.6	
	10,000	253.6	-50.1		36	0.01	nw.	44.6	

¹ Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929*—Continued

DECEMBER 19, 1929—Continued

Time 90th mer.	Altitude (M.S.L.)	Pressure	Temperature	$\frac{\Delta t}{100 \text{ m.}}$	Humidity Relative	Humidity Vapor pressure	Wind Direction	Wind Velocity	Remarks
P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
5:01	10,401	238.6	—49.9	—0.05	36	0.01			
	11,000	217.9	—50.5		36	0.01			
5:07	11,806	193.0	—51.3	0.10	36	0.01			
	12,000	187.1	—52.5		36	0.01			
5:14	12,515	172.5	—55.8	0.63	35	0.01			
	13,000	160.3	—55.8		35	0.01			
5:19	13,353	151.8	—55.8	0.00	35	0.01			
5:21	13,766	142.4	—58.3	0.61	35	(¹)			
	14,000	137.4	—59.1		35	(¹)			
5:25	14,355	130.0	—60.3	0.34	34	(¹)			
	15,000	117.6	—60.4		34	(¹)			
	16,000	100.7	—60.5		34	(¹)			
	17,000	85.9	—60.5		34	(¹)			
	18,000	73.3	—60.6		34	(¹)			
5:48	18,704	65.3	—60.7	0.01	34	(¹)			

DECEMBER 20, 1929

Time 90th mer.	Altitude (M.S.L.)	Pressure	Temperature	$\frac{\Delta t}{100 \text{ m.}}$	Relative	Vapor pressure	Direction	Velocity	Remarks
P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
4:01	233	999.9	1.0		49	3.21	w.	2.0	1 Ci., WSW.
	500	967.0	—1.9		49	2.56	w.	4.9	
4:04	849	925.3	—5.6	1.07	49	1.88	wnw.	5.6	
	1,000	907.6	—7.1		50	1.68	wnw.	6.2	
	1,500	850.6	—12.2		52	1.12	wnw.	7.5	
4:08	1,620	837.5	—13.4	1.01	53	1.02	wnw.	9.4	
	2,000	796.6	—12.9		56	1.13	wnw.	12.2	
4:10	2,034	793.1	—12.9	—0.12	57	1.15	wnw.	12.0	
4:11	2,317	764.2	—13.8	0.32	57	1.06	wnw.	12.0	
4:12	2,479	748.2	—13.3	—0.31	54	1.05	wnw.	12.5	
	2,500	746.1	—13.4		54	1.04	wnw.	12.6	
	3,000	698.5	—16.1		51	0.77	wnw.	12.2	
4:16	3,443	658.3	—18.5	0.54	49	0.59	wnw.	15.1	
4:17	3,676	638.4	—17.3	—0.52	45	0.61	wnw.	16.0	
	4,000	611.1	—18.9		49	0.57	wnw.	9.8	
4:23	4,939	538.1	—23.7	0.51	59	0.43	w.	20.9	
	5,000	533.8	—24.1		59	0.41	w.	21.2	
	6,000	465.0	—30.0		57	0.22	w.	28.0	
4:30	6,478	434.9	—32.8	0.59	56	0.16	w.	38.2	
	7,000	403.7	—36.0		53	0.11	w.	38.5	
	8,000	349.2	—42.2		48	0.05	wsw.	44.8	
4:37	8,652	317.3	—46.2	0.62	45	0.03	wsw.	46.5	Tropopause.
4:38	8,880	306.8	—45.5	—0.31	44	0.03	wsw.	45.9	
	9,000	301.4	—45.7		44	0.03	wsw.	44.8	
	10,000	260.3	—47.1		44	0.02	wsw.	51.6	
	11,000	224.2	—48.6		43	0.02	wsw.	49.3	
	12,000	192.7	—50.1		43	0.02	wsw.	48.0	
4:49	12,087	189.7	—50.7	0.16	43	0.02	wsw.	48.8	
	13,000	165.2	—52.0		43	0.01	w.	42.2	
	14,000	141.7	—53.3		43	0.01	w.	25.6	
	15,000	121.5	—54.7		43	0.01	w.	21.2	
	16,000	104.0	—56.1		43	0.01	w.	28.9	
5:01	16,861	90.7	—57.3	0.14	43	0.01	w.	19.8	
	17,000	88.6	—57.5		43	0.01	w.	18.7	
	18,000	75.8	—59.3		43	(¹)	w.	17.3	
5:09	18,927	65.7	—60.9	0.17	43	(¹)	w.	7.1	
	19,000	64.8	—60.8		43	(¹)	w.	6.8	
	20,000	55.5	—59.1		42	(¹)			
5:24	20,355	52.3	—58.5	—0.17	42	0.01			

DECEMBER 21, 1929

Time 90th mer.	Altitude (M.S.L.)	Pressure	Temperature	$\frac{\Delta t}{100 \text{ m.}}$	Relative	Vapor pressure	Direction	Velocity	Remarks
P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
4:26	233	1,004.7	—2.5		52	2.58	n.	3.6	4 Ci., SSW.; 5 Ci. St., SW.
	500	971.2	—4.8		53	2.17	nnw.	6.3	
4:29	873	926.1	—8.1	0.88	55	1.70	nnw.	5.7	
	1,000	911.1	—8.0		53	1.65	nnw.	5.5	
4:30	1,404	864.8	—7.7	—0.06	47	1.50	nnw.	4.7	
	1,500	854.3	—8.1		47	1.45	nnw.	4.9	
	2,000	800.9	—10.1		46	1.20	nnw.	5.8	
4:33	2,391	761.3	—11.6	0.40	45	1.02	nw.	4.7	
	2,500	750.5	—12.2		44	0.95	nw.	4.9	
	3,000	702.7	—14.7		42	0.72	wnw.	7.6	
4:37	3,389	667.4	—16.7	0.50	40	0.57	wnw.	8.9	
	4,000	615.3	—19.5		40	0.44	wnw.	7.4	
4:39	4,184	600.4	—20.3	0.45	40	0.40	w.	7.5	
	5,000	537.5	—23.5		40	0.30	wsw.	16.4	
4:41	5,096	530.4	—23.9	0.39	40	0.29	wsw.	17.7	
	6,000	468.0	—31.2		40	0.14	wsw.	23.7	
4:46	6,613	429.2	—36.1	0.80	40	0.08	sw.	30.2	
	7,000	405.7	—39.9		40	0.05	sw.	29.4	
4:50	7,728	364.8	—47.1	0.90	40	0.02			Tropopause.
4:51	7,999	350.5	—46.3	—0.30	40	0.02			
	9,000	301.7	—49.6		39	0.02			
4:55	9,597	275.7	—51.5	0.32	38	0.01			
	10,000	259.6	—51.0		38	0.01			
4:58	10,705	233.2	—50.1	—0.13	38	0.01			
	11,000	222.7	—50.8		38	0.01			
	12,000	191.5	—53.0		38	0.01			
	13,000	164.0	—55.3		38	0.01			

¹ Less than 0.01 mb.

DECEMBER 21, 1929—Continued

Time 90th mer.	Altitude, M.S.L.	Pressure	Temperature	$\frac{\Delta t}{100 \text{ m.}}$	Relative	Vapor pressure	Direction	Velocity	Remarks
P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
5:06	13,108	161.2	—55.5	0.22	38	0.01			
5:07	13,199	158.8	—54.5	—1.00	38	0.01			
	14,000	140.5	—55.4		38	0.01			
5:10	14,072	138.7	—55.5	0.11	38	0.01			
	15,000	120.0	—60.4		38	(¹)			
5:16	15,294	114.5	—62.0	0.53	38	(¹)			
	16,000	102.3	—62.3		38	(¹)			
5:19	16,334	97.0	—62.5	0.05	38	(¹)			

DECEMBER 22, 1929

Time 90th mer.	Altitude, M.S.L.	Pressure	Temperature	$\frac{\Delta t}{100 \text{ m.}}$	Relative	Vapor pressure	Direction	Velocity	Remarks
P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
3:32	233	998.4	—0.7		44	2.54	n.	3.1	Cloudless.
	500	966.1	—3.5				n.	4.6	
	1,000	904.3	—8.9				n.	8.2	
3:36	1,192	882.2	—10.9	1.06			n.	6.4	
	1,500	848.7	—11.3				nnw.	9.0	
3:38	1,551	841.9	—11.4	0.14			nnw.	9.0	
	2,000	794.5	—13.7				wnw.	10.4	
3:42	2,448	748.2	—16.0	0.51			wnw.	10.6	
	2,500	743.5	—16.3				wnw.	10.4	
	3,000	693.7	—19.5				wnw.	11.3	
3:48	3,853	614.7	—25.1	0.63			wnw.	13.3	
	4,000	605.4	—25.9				wnw.	14.0	
	5,000	526.8	—32.8				wnw.	29.0	
3:55	5,558	484.2	—36.6	0.70			wnw.	35.0	
	6,000	457.3	—38.2				wnw.	34.9	
	7,000	395.8	—41.7				wnw.	42.6	
4:00	7,039	390.2	—41.8	0.35			wnw.	42.6	
	8,000	341.2	—46.8				wnw.	39.6	
	9,000	293.6	—52.1				w.	34.4	
4:10	9,386	273.5	—54.1	0.52			w.	35.0	Tropopause.
	10,000	251.4	—54.0				w.	27.6	
	11,000	215.4	—53.9				w.	36.3	
	12,000	185.3	—53.7				w.	29.5	
4:20	12,066	180.3	—53.7	—0.01			w.	23.0	
	13,000	159.5	—56.0				wsw.	28.2	
	14,000	137.2	—58.4						
	15,000	117.3	—60.9						
4:37	15,780	100.1	—62.8	0.25					

DECEMBER 23, 1929

Time 90th mer.	Altitude, M.S.L.	Pressure	Temperature	$\frac{\Delta t}{100 \text{ m.}}$	Relative	Vapor pressure	Direction	Velocity	Remarks
P.m.	M.	Mb.	°C.		P.ct.	Mb.		M.p.s.	
4:12	233	994.4	5.0		48	4.19	sw.	4.9	Cloudless.
	500	962.1	2.9				ssw.	8.0	
	1,000	904.1	—1.0				sw.	7.9	
4:16	1,079	895.2	—1.6	0.78			sw.	7.8	
4:18	1,423	857.3	—2.3	0.20			wsw.	11.7	
	1,500	849.0	—2.6				w.	11.8	
4:20	1,872	809.9	—4.3	0.45			w.	8.4	
	2,000	796.9	—4.3				w.	7.9	
4:21	2,146	782.3	—4.2	—0.04			w.	7.9	
	2,500	747.7	—6.0				wnw.	11.2	
	3,000	701.2	—8.6				nw.	12.9	
4:27	3,313	673.5	—10.2	0.51			nw.	14.5	
	4,000	615.7	—14.4				nw.	16.5	
4:31	4,234	597.0	—15.8	0.61			nw.	16.0	
	5,000	539.5	—18.5				nnw.	28.7	
4:36	5,269	520.2	—19.4	0.35			nnw.	28.0	
	6,000	470.9	—24.7				nnw.	30.7	
4:41	6,634	431.6	—29.3	0.73			nnw.	34.8	
	7,000	410.0	—32.1				n.	35.7	
	8,000	355.5	—39.9				n.	37.1	
4:49	8,729	319.7	—45.5	0.77			nnw.	36.2	
	9,000	306.8	—48.3				nnw.	42.2	
4:56	9,820	271.1	—56.8	1.04			nnw.	43.8	Tropopause.
	10,000	263.8	—56.8				nnw.	42.6	
4:57	10,419	247.0	—56.8	0.00			nnw.	35.9	
	11,000	225.9	—59.8				nnw.	28.7	
5:00	11,176	219.8	—60.7	0.52			nw.	28.5	
5:04	11,822	198.6	—54.0	—1.04			wnw.	24.4	
	12,000	193.4	—54.0				wnw.	19.2	
	13,000	166.4	—54.3				w.	33.3	
	14,000	142.4	—54.5				w.	24.8	
	15,000	122.0	—54.8				w.	27.8	
5:08	15,558	111.6	—54.9	0.02			w.	24.4	
	16,000	104.5	—55.4				w.	24.3	
	17,000	89.7	—56.5				w.	27.3	
	18,000	76.8	—57.7				wnw.	18.4	
	19,000	65.7	—58.8				wnw.	19.5	
	20,000	55.9	—59.9				w.	22.0	
	21,000	47.6	—61.1				w.	22.3	
	21,289	45.5	—61.4	0.11			w.	17.8	

¹ Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929*—Continued

DECEMBER 24, 1929

Time 90th mer.	Altitude (M. S. L.)	Pressure	Temperature	Δt 100 m.	Humidity Relative	Humidity Vapor pressure	Wind Direction	Wind Velocity	Remarks
P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
4:04	233	991.3	11.8	-----	45	6.23	w.	3.6	Cloudless.
	500	960.0	10.2	-----	46	5.72	w.	6.2	
4:06	923	912.2	7.6	0.61	48	5.01	wnw.	8.4	
	1,000	903.7	7.9		48	5.11	nw.	9.3	
4:07	1,063	896.9	8.1	-0.36	48	5.18	nw.	10.0	
	1,500	850.1	4.5		49	4.13	nw.	14.1	
	2,000	799.1	0.3		49	3.06	nw.	15.7	
4:13	2,454	754.8	-3.5	0.83	50	2.29	nw.	14.2	
	2,500	750.6	-3.8		50	2.23	nw.	14.3	
	3,000	704.4	-7.2		49	1.64	nw.	17.3	
	4,000	618.8	-13.9		46	0.85	nw.	22.6	
4:18	4,085	611.9	-14.5	0.67	45	0.80	nw.	24.4	
4:19	4,399	586.9	-15.2	0.22	45	0.74	nw.	27.4	
	5,000	541.8	-18.8		45	0.53	nw.	28.7	
4:22	5,327	518.8	-20.8	0.60	45	0.44	nnw.	29.7	
	6,000	473.4	-24.7		42	0.28	nnw.	44.4	
4:26	6,457	444.8	-27.4	0.58	40	0.20	nnw.	45.1	
4:27	6,570	438.0	-27.8	0.35	39	0.19	nnw.	45.3	
	7,000	412.5	-31.4		37	0.12	n.	50.7	
4:31	7,694	374.0	-37.3	0.85	35	0.06	n.	50.8	
	8,000						nnw.	52.0	
	9,000						nnw.	44.8	
	10,000						nnw.	28.4	
	10,609						nw.	25.0	
	11,000						wnw.	34.9	
	12,000						wnw.	24.9	
	13,000						wnw.	20.0	
	13,070						wnw.	20.0	

DECEMBER 25, 1929

Time 90th mer.	Altitude	Pressure	Temperature	Δt 100 m.	Relative	Vapor pressure	Direction	Velocity	Remarks
P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
3:49	233	989.0	16.6	-----	28	5.29	sw.	0.7	Cloudless.
	500	958.2	15.0		31	5.29	ssw.	12.3	
	1,000	903.0	11.9		37	5.15	wsw.	16.5	
3:53	1,211	880.4	10.6	0.61	39	4.98	wsw.	17.5	
3:54	1,402	860.7	12.6	-1.05	36	5.25	w.	18.0	
3:54½	1,500	850.6	11.5	1.12	35	4.75	w.	17.0	
	2,000	800.9	8.9		36	4.10	w.	13.3	
	2,500	753.7	6.3		37	3.53	w.	13.1	
3:58	2,619	743.0	5.7	0.52	37	3.39	w.	13.5	
	3,000	709.1	2.8		36	2.69	wnw.	15.2	
4:02	3,559	661.7	-1.4	0.76	35	1.90	nw.	14.4	
	4,000	625.7	-4.6		35	1.46	wnw.	16.9	
4:06	4,528	585.0	-8.4	0.72	35	1.05	nw.	17.7	
	5,000	550.7	-11.2		36	0.85	nw.	17.9	
4:08	5,158	539.4	-12.1	0.59	36	0.78	wnw.	18.7	
	6,000	482.6	-18.0		24	0.30	nw.	19.5	
4:13	6,186	470.9	-19.3	0.70	21	0.24	nw.	19.4	
	7,000	421.9	-25.0		21	0.13	nw.	19.9	
4:16	7,165	412.5	-26.2	0.70	21	0.12	nw.	20.7	
	8,000	367.2	-33.7		21	0.05	nw.	24.1	
4:21	8,427	345.5	-37.6	0.90	21	0.04	nw.	23.6	
4:23	8,893	323.6	-40.8	0.69	21	0.02	wnw.	23.7	
	9,000	318.4	-41.5		21	0.02	nw.	23.8	
4:24	9,235	307.8	-43.1	0.67	20	0.02	nw.	26.3	
	10,000	274.8	-48.5		20	0.01	nw.	25.1	
	11,000	236.4	-55.6		20	(1)	nw.	21.6	
4:31	11,564	216.9	-59.6	0.71	20	(1)	nw.	24.7	
	12,000	202.8	-62.4		20	(1)	nw.	21.6	Tropopause.
4:34	12,212	196.1	-63.8	0.65	20	(1)	nw.	23.1	
	13,000	173.4	-59.7		20	(1)	nw.	21.3	
4:38	13,204	168.0	-58.7	-0.51	20	(1)	wnw.	20.0	
4:39	13,444	161.6	-58.4	-0.12	20	(1)	wnw.	23.1	
4:40	13,706	155.3	-58.7	0.11	20	(1)	nw.	26.4	
	14,000	148.2	-59.3		20	(1)	nw.	26.7	
4:42	14,409	139.2	-60.1	0.20	20	(1)	nw.	23.9	
4:44	14,642	133.9	-60.5	0.17	19	(1)	nw.	24.8	
	15,000	126.9	-59.9		19	(1)	nw.	18.5	
4:45	15,036	126.2	-59.8	-0.18	19	(1)	nw.	18.2	
	16,000	108.5	-61.4		19	(1)	wnw.	16.4	
	17,000	92.4	-63.2		19	(1)	w.	11.0	
4:53	17,087	91.0	-63.3	0.17	19	(1)	w.	12.4	
	18,000	78.9	-62.7		18	(1)	wnw.	8.5	
5:01	18,866	68.7	-62.1	-0.07	18	(1)	wnw.	12.0	
	19,000	67.2	-61.9		18	(1)	wnw.	12.1	
	20,000	57.5	-60.2		18	(1)	wnw.	10.9	
5:10	20,988	49.2	-58.6	-0.16	18	(1)	w.	6.4	
	21,000	49.1	-58.6		18	(1)	w.	6.4	
	22,000	42.1	-56.7		18	(1)			
5:17	22,921	36.4	-54.9	-0.19	18	(1)			

1 Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929*—Continued

DECEMBER 27, 1929

Time 90th mer.	Altitude (M. S. L.)	Pressure	Temperature	Δt 100 m.	Humidity Relative	Humidity Vapor pressure	Wind Direction	Wind Velocity	Remarks
P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
4:21	233	992.3	9.4	-----	49	5.78	n.	3.8	Cloudless.
	500	960.6	7.3		47	4.80	nnw.	6.0	
4:24	896	915.3	4.3	0.77	45	3.74	nnw.	8.9	
	1,000	903.7	4.2		44	3.63	n.	10.0	
4:25	1,195	882.3	4.1	0.07	41	3.36	n.	10.4	
	1,500	849.6	2.7		41	3.04	nnw.	9.8	
	2,000	798.6	0.5		40	2.53	nw.	11.0	
	2,500	750.2	-1.7		39	2.07	nw.	10.2	
4:31	2,623	738.6	-2.3	0.04	39	1.97	nw.	9.9	
4:33	2,928	710.9	-3.2	0.30	39	1.83	nw.	10.5	
	3,000	704.1	-3.7		39	1.76	wnw.	10.9	
	4,000	614.4	-10.5		41	1.03	wnw.	14.7	
4:38	4,154	601.2	-11.5	0.68	41	0.94	wnw.	15.4	
	5,000	541.7	-18.1		38	0.48	wnw.	11.3	
4:43	5,267	524.4	-20.2	0.78	37	0.38	wnw.	10.5	
4:45	5,790	489.0	-21.7	0.29	39	0.35	wnw.	14.8	
	6,000	475.1	-23.2		38	0.29	wnw.	16.0	
	7,000	414.0	-30.5		36	0.13	nw.	20.2	
4:52	7,451	388.4	-33.8	0.73	35	0.09	nw.	22.8	
	8,000	359.4	-38.2		36	0.06	wnw.	25.2	
	9,000	310.4	-46.2		38	0.02	w.	26.9	
5:00	9,660	281.4	-51.5	0.80	39	0.01	w.	27.9	Tropopause.
	10,000	267.8	-51.7		39	0.01	w.	33.1	
	11,000	230.6	-52.2		39	0.01	w.	36.9	
	12,000	197.9	-52.8		39	0.01	w.	33.3	
5:09	12,805	174.6	-53.2	0.05	39	0.01	w.	35.8	
	13,000	169.7	-53.6				wsw.	36.0	
	14,000	145.6	-55.7				w.	33.7	
	15,000	124.4	-57.8				w.	28.8	
5:17	15,938	107.4	-59.8	0.21			w.	27.6	
	16,000	106.2	-60.0				w.	27.3	
	17,000	90.7	-63.7				wsw.	21.0	
	18,000	77.3	-67.4				w.	15.0	
	19,000	65.5	-71.0						
5:29	19,078	64.8	-71.3	0.37					

DECEMBER 28, 1929

Time 90th mer.	Altitude	Pressure	Temperature	Δt 100 m.	Relative	Vapor pressure	Direction	Velocity	Remarks
P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
4:22	233	995.6	9.8	-----	32	3.88	n.	6.7	Cloudless.
	500	964.0	7.0		32	3.41	n.	10.4	
4:26	935	914.1	4.8	0.71	32	2.75	nnw.	10.2	
	1,000	907.0	4.3		32	2.66	nnw.	10.4	
	1,500	850.3			30	2.58	nw.	15.0	
4:29	1,596	842.3	-0.4	0.79	30	1.77	nw.	16.2	
4:30	1,759	825.3	-1.8	0.55	25	1.37	nw.	17.2	
	2,000	800.7	-2.8		26	1.26	nw.	19.3	
	2,500	751.6	-5.9		30	1.12	nw.	26.2	
4:35	2,906	713.4	-8.4	0.62	32	0.96	nw.	28.5	
	3,000	704.8	-8.4		32	0.96	nw.	30.0	
4:38	3,386	670.7	-8.4	0.00	34	1.02	nw.	33.5	
	4,000	620.5	-14.0		37	0.68	nw.	39.1	
4:42	4,096	613.2	-14.9	0.92	37	0.63	nw.	37.8	
4:44	4,376	591.5	-13.6	-0.46	34	0.65	wnw.	34.4	
	5,000	544.5	-18.6		34	0.40	wnw.	33.4	
4:50	5,831	486.6	-25.3	0.80	35	0.22	wnw.	33.8	
	6,000	475.5	-26.6		35	0.19	wnw.	34.0	
	7,000	413.5	-34.5		35	0.08	wnw.	35.0	
4:55	7,222	400.7	-36.2	0.78	35	0.07	wnw.	39.2	
4:56	7,430	388.8	-37.3	0.53	33	0.06	wnw.	41.2	
	8,000	358.2	-41.0		32	0.04	wnw.	40.8	
5:01	8,480	334.1	-44.2	0.66	32	0.02	w.	46.3	
5:02	8,600	328.0	-43.3	-0.75	32	0.03	w.	48.0	
	9,000	309.5	-46.5		31	0.02	w.	47.8	
5:07	9,807	274.2	-53.0	0.80	28	0.01	w.	53.9	Tropopause.
	10,000	266.4	-52.2		30	0.01	w.	47.4	
5:08	10,183	259.2	-51.4	-0.43	32	0.01	w.	49.0	
	11,000	228.8	-54.4		31	0.01	w.	51.0	
5:13	11,428	214.4	-55.9	0.36	30	0.01	w.	37.5	
	12,000	196.5	-55.7		27	0.01	w.	41.2	
	13,000	168.2	-55.5			(1)			
5:20	13,320	159.9	-55.4	-0.26	21	(1)			
5:23	13,772	149.2	-58.0	0.58	21	(1)			
	14,000	143.9	-58.0		21	(1)			
	15,000	123.0	-57.7		21	(1)			
5:30	15,141	120.3	-57.7	-0.22	21	(1)			
	16,000	105.2	-60.6		21	(1)			
5:35	16,521	96.9	-62.3	0.33	21	(1)			
	17,000	89.8	-62.0			(1)			
	18,000	76.7	-61.0			(1)			
5:51	18,519	70.7	-60.6	-0.85		(1)			

1 Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents made at Broken Arrow, Okla., during December, 1929*—Continued

DECEMBER 29, 1929

Time 90th mer.	Altitude (M.S.L.)	Pressure	Temperature	Δt 100 m.	Humidity		Wind		Remarks
					Relative	Vapor pressure	Direction	Velocity	
P. m.	M.	Mb.	°C.		P. ct.	Mb.		M.p.s.	
3:44....	233	991.9	16.6		32	6.05	sw.	5.8	Cloudless.
	500	961.1	14.6	------	32	5.32	wsw.	8.6	
3:47....	928	913.3	11.5	0.73	32	4.34	wsw.	10.6	
	1,000	905.4	11.0	------	32	4.20	wsw.	11.3	
3:49....	1,490	853.5	7.8	0.66	32	3.39	w.	19.0	
	1,500	852.5	7.8	------	32	3.39	w.	19.0	
	2,000	802.3	8.9	------	30	2.98	wnw.	17.5	
3:52....	2,122	790.4	6.7	0.17	30	2.94	wnw.	16.9	
	2,500	754.7	4.9	------	31	2.68	wnw.	16.2	
	3,000	709.7	2.4	------	32	2.32	nw.	14.1	
3:59....	3,711	649.9	-1.0	0.48	34	1.91	nw.	17.0	
	4,000	626.7	-2.5	------	34	1.69	nw.	19.3	
	5,000	551.9	-7.7	------	35	1.12	wnw.	20.8	
4:04....	5,025	550.2	-7.8	0.52	35	1.11	wnw.	20.8	
	6,000	484.3	-16.2	------	32	0.48	nw.	18.8	
4:11....	6,626	446.0	-21.6	0.86	30	0.27	nnw.	23.2	
	7,000	423.8	-25.0	------	30	0.19	nnw.	25.0	
4:15....	7,728	383.1	-31.8	0.93	30	0.10	nw.	22.5	
	8,000	369.0	-33.7	------	30	0.08	nw.	21.2	
	9,000	320.1	-40.9	------	29	0.03	n.	26.6	
4:22....	9,686	289.7	-45.8	0.66	28	0.02	n.	30.0	Tropopause.
	10,000	276.3	-45.9	------	28	0.02	nnw.	23.1	
4:24....	10,339	262.8	-46.0	0.03	28	0.02	nw.	19.8	
	11,000	238.5	-48.0	------	27	0.01	nw.	20.6	
	12,000	205.5	-50.9	------	26	0.01	nw.	34.6	
4:31....	12,828	181.0	-53.4	0.30	25	0.01	nnw.	20.1	
	13,000	176.5	-54.0	------	25	0.01	nnw.	23.6	
	14,000	151.4	-57.5	------	25	(1)	nw.	20.2	
	15,000	129.5	-61.1	------	25	(1)	nw.	20.0	
4:42....	15,738	115.4	-63.7	0.35	25	(1)	nnw.	17.6	
	16,000	110.7	-63.8	------	25	(1)	nnw.	13.3	
	17,000	94.4	-64.0	------	25	(1)	nnw.	11.8	
4:50....	17,555	86.4	-64.1	0.02	25	(1)	nnw.	14.6	
	18,000	80.5	-63.4	------	25	(1)	nnw.	14.4	
4:54....	18,550	73.6	-62.6	-0.15	25	(1)	nw.	20.2	

[1] Less than 0.01 mb.

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WIND VELOCITIES AT DIFFERENT HEIGHTS ABOVE GROUND

By C. F. MARVIN

A correspondent inquires whether the Weather Bureau has made any investigations to determine the relative wind velocity as indicated by an anemometer at different heights above ground. The following reply was made:

Replying to your telegram of August 21, requesting information as to velocities indicated by anemometers at different heights above the ground, you are advised that the Weather Bureau has conducted a number of inconclusive comparisons of wind velocities measured at its stations at different elevations, with the hope that some rational rule would result for coordinating the indications at various heights. Thus far, however, we have not felt justified in announcing any such coordination or formula, so to speak, for reduction to uniform elevations.

The demands upon the bureau for service to the public in great metropolitan and other city areas compel us to occupy quarters such as can be procured in these cities. It is recognized that the wind-velocity records obtained under these conditions are not entirely satisfactory. If one contemplates the skyline of the modern great city, it is obvious that the flow of air over the house tops and among the skyscrapers is turbulent and difficult to measure with any specially significant result. On the other hand, observations made in the open country or in cities of moderate population necessarily represent only those localities, and can not, with assurance, be applied to other localities. Our policy, therefore, has been to submit records as obtained, without attempting to modify or adjust these records, and to supply to any interested person a complete description of the environment and nature of exposure of the anemometer at the particular station, leaving it to the user of the records to make such correlations with environment as may seem to him to be best.

Apart from the foregoing, you are further advised that various comparative observations have been made for winds at different altitudes over an open plain or country, and one formula for increase of velocity is approximately

$$V = V_o \left(\frac{h}{h_o}\right)^{\frac{1}{5}}$$

where h is the height in meters above the surface for which the velocity V in meters per second is to be computed, and h_o the known height (not less than 16 meters) at which the velocity V_o is measured. There are still other relations that cover the general increase in velocity upward for much greater elevations. I infer, however, that you are interested only in elevations of several hundred feet above the actual surface.

THE WEATHER AND RADIO

By W. J. HUMPHREYS

It appears to be human nature to explain whatsoever is not understood by attributing it to something that is still more mysterious, or even to the supernatural. At any rate this is a very common human practice, as excellently illustrated by the many appeals that have come to the Weather Bureau to have radio broadcasting suppressed, on the ground that it is burning up the water vapor of the air and thereby, or in some other manner, greatly decreasing the amount of rainfall, and thus causing disastrous droughts.

On the other hand, some who were bothered with more rain than needed were equally insistent that radio is the cause of excessive precipitation and floods, and urged that therefore all wireless communication be forthwith and preemptorily forbidden.

Let us analyze somewhat nature's way of making rain, and from that see, if we can, just how and to what extent radio does affect precipitation.

1. The first action necessary to precipitation is evaporation, by which water in the gaseous form is gotten into and made a portion of the atmosphere. Now the chief factors that affect the rate of evaporation are: (a) Temperature of the evaporating water; (b) area of the evaporating surface; (c) wind velocity; (d) dryness of the air.

Of course no one in the neighborhood of a powerful "sending station" ever claims that any lake, reservoir or other body of water near-by, spreads over a lot more ground when the station is in operation than it does when the station is silent. He knows, too, that the temperature of the water does not appreciably vary, if at all, with the wireless activity. Neither, so far as any one can observe, does the wind round about a wireless station change with the amount of its broadcasting or receiving. We shall see presently, too, that radio does not alter the dryness of the air.

Obviously, since radio does not affect any of the things that themselves make for evaporation, neither does it affect evaporation itself.

2. The next step by nature in producing rain is to condense the water vapor out of the air in the form of drops. To this end two things are necessary: (a) One of these is the presence of condensation nuclei, that is, excessively small particles of sea salt, certain kinds of land dust, or other substances that readily take up water vapor. These nuclei about which cloud droplets form always are in the atmosphere in superabundance. Besides, they are not produced by wireless waves, as we know by direct experiment. (b) The other essential to

get the water vapor condensed is an adequate cooling of the vapor, and with it (unavoidably) the other elements of the atmosphere. But the temperature of the air does not go down about an active wireless station any more rapidly, nor to a lower degree, than it does at other similarly located places.

Evidently, then, radio does not take water vapor out of the air and make it drier, thus increasing evaporation and subsequent rainfall. Neither does it prevent or decrease rainfall since it has no effect on any of the factors of either evaporation or condensation.

Again, drought may prevail in one region at the same time that another, with equal wireless facilities, is being flooded. Furthermore, droughts and floods, such as we

now have, prevailed time and again throughout the world long before wireless was ever dreamed of.

Finally, from purely theoretical considerations, we know that the relatively small amount of energy used in broadcasting is not sufficient by millions of fold to produce any appreciable change in the amount of precipitation over either the United States as a whole, or even any one of its units.

However much radio may be affected by the weather, especially by the thunderstorm, no element of the weather is affected in turn by radio. We know this from experiment and observation, and we know it from theory as well.

AN ERROR IN THE MAXIMUM-THERMOMETER READING

By W. J. HUMPHREYS

In the case of the mercurial maximum thermometer that breaks its column at a point of constriction the reading always is too low if made after appreciable cooling. This is well known, but perhaps not as generally recognized and fully understood as it might be.

Let

V_m = the stem volume between consecutive degree marks at the time of maximum temperature.

V_t = the stem volume between consecutive degree marks when the temperature is t.

t_o = the stem reading at the point of break of column.

t = the temperature at time of reading.

t_m = the true maximum temperature.

t'_m = the maximum temperature as read.

M = the coefficient of the *volume* expansion of mercury.

G = the coefficient of the *volume* expansion of the thermometer stem—threefold the coefficient of its linear expansion.

The volume of the mercury column at the time of maximum temperature, is, of course, the volume of that portion of the stem then filled. That is, at the temperature t_m

Volume of mercury = volume of glass = $V_m(t_m - t_o)$

At the time of reading, however, or when the mercury has cooled from t_m to t, the volume of this same mass of mercury is

$V_m(t_m - t_o) - MV_m(t_m - t_o)(t_m - t)$, or $V_m(t_m - t_o)\{1 - M(t_m - t)\}$

while the original occupied stem volume has become

$V_m(t_m - t_o)\{1 - G(t_m - t)\}$

Hence the apparent or virtual shrinkage of the mercury, being the difference between the true shrinkage of the mercury and the true shrinkage of the glass, is

$V_m(t_m - t_o)(M - G)(t_m - t)$

Now the error of the reading evidently is the number of the unit stem volumes (volume between consecutive degree marks) whose total volume at the time of observation, when the temperature is t, is equal to the virtual

shrinkage of the mercury since the temperature was t_m. Let this number be x, then

$$xV_t = V_m(t_m - t_o)(M - G)(t_m - t)$$
$$= V_m(t'_m + x - t_o)(M - G)(t'_m + x - t)$$

From this equation the numerical value of x, the error in question in degrees, could be computed if we knew the ratio of V_m to V_t, since the values of all the other terms are known. Clearly,

$$V_t = V_m\{1 - G(t'_m + x - t)\}$$

But since G is very small, 0.000025, about, per degree centigrade, and $t_m - t$ seldom large, say, 20° C. at most, it follows that no observable error will be made by assuming V_t and V_m to be exactly equal to each other. With this assumption the value of x is readily computed.

To simplify, let

$$M - G = d$$
$$t'_m - t_o = a$$
$$t'_m - t = b$$

Then

$$x = (a + x)d(b + x)$$

Finally, since x is very small in comparison with either a or b, we can, without measureable error, write

$$x = adb$$
$$= (t'_m - t_o)(M - G)(t'_m - t)$$

the form in which the value of this error commonly is expressed.

In practice this error, or value of x, seldom amounts to more than 0.1° F. or 0.2° F., and therefore for most purposes is negligible. It might be sufficient, however, to change a Weather Bureau's telegraphed value by 2°. Thus, suppose the reading taken just after maximum, is 91°+, F., and the reading some time later, following considerable cooling, 91°−, F. Owing to code exigencies the first would be reported as 92° F., and the second as 90° F. Fortunately, though, even this occasional error is of little importance, since it is the permanent station record of actual readings and not the ephemeral telegraphed reports that are considered in climatological and kindred studies.

In short this particular error of the maximum thermometer is of little to no importance in meteorology. Nevertheless, it is pleasant to know that there is such an error and reassuring to understand clearly when and why it may be ignored.

A REMARKABLY HEAVY RAINSTORM IN THE CHICAGO AREA

By O. T. LAY

On the night of August 10–11, 1931, a remarkably heavy rainstorm occurred in the Chicago area. The total amount of rainfall at the main observatory of the Weather Bureau, on the campus of the University of Chicago, during a period of slightly more than 10 hours, beginning at 8:47 p. m. on the 10th, was the heaviest of record since 1885, and among the heaviest for the entire 61 years of record. The totals of 1.22 inches within 15 minutes and 1.39 inches within 20 minutes broke all previous records for similar periods. Basements and subways in much of the city were flooded, and other damage resulted from the rain and accompanying wind.

RAINFALL DISTRIBUTION IN THE CHICAGO AREA
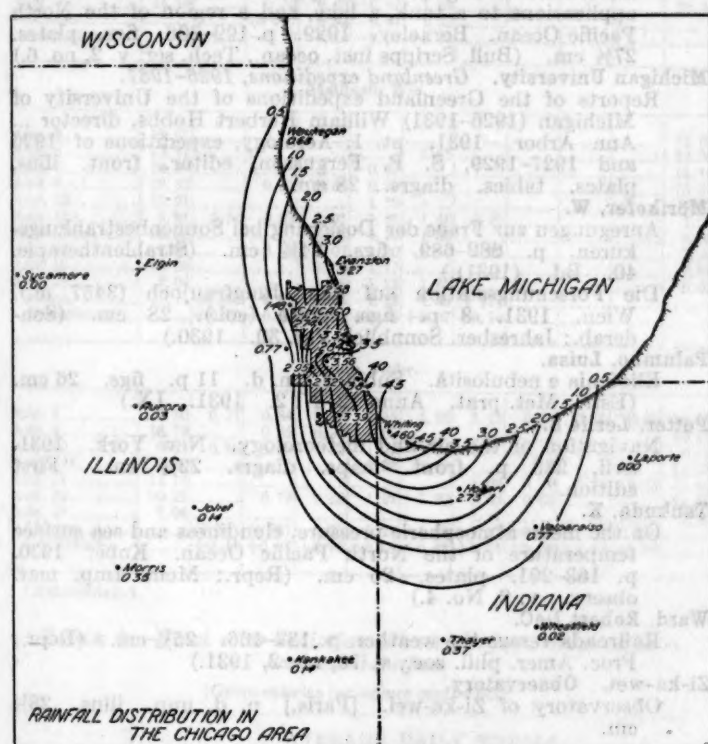
The rainfall was heaviest along the lake front in and immediately to the southeast of the city, the greatest totals being 4.60 inches at Whiting, Ind., and 3.84 inches at the Weather Bureau observatory at the University of Chicago. Amounts decreased rapidly at stations in all directions from an area including these two points. At Laporte, Ind., 40 miles to the east of Whiting, and Sycamore, Ill., 50 miles to the west of the city limits of Chicago, no rain whatever occurred.

The wind varied from northeast to northwest, and the rainfall was heaviest along those parts of the lake front that received the most direct "lake" wind. There was no general storm area in the region, and the barometer was either stationary or rising slowly during the storm. The

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temperature at Chicago fell from about 70° at the beginning of the storm to 56° at midnight on the 10th, when one of the heavy downpours occurred, rose slightly for some time thereafter, then fell again to 57° in the early morning of the 11th, when another very heavy downpour occurred. Apparently an inflow of comparatively cold air aloft from over the lake was responsible to a considerable extent for the rapid condensation from moist air over the land area adjacent to those portions of the lake from which the cold air approached.

The accompanying chart shows the distribution of rainfall as measured at stations of the Weather Bureau, the Sanitary District, and the Bureau of Water Safety Control of the City of Chicago.

MORE RAIN IN DROUGHT YEAR [1]

Missouri has advanced thus far through the crop season with a total rainfall comparable in many ways with the rainfall of 1930, the great drought year. And as with Missouri, so with many of the States of the central crop area.

Last year the shortage caused famine conditions in many sections; this year crops, generally, are fair to good to excellent. Up to July 1 in Missouri the 1931 rainfall just about balanced that of last year, with the advantage, slight as it was, with the drought year. In 1930 Missouri rainfall up to and including June was 82 per cent of normal and this year it was only 81 per cent of normal.

The difference was that the 1930 rains came in unusual quantities in January and February and the four months to follow were unusually dry. This year, the first two months of the year were very dry and general, though light, rains fell during the four months that followed. The distribution, according to season, was better this year than last and the advantage was shown in the crop variations of the two years. But in 1930 the July rain was only 24 per cent of normal, while this year the percentage was 81, with considerable damage to corn at a critical period.

Besides supplying crops with needed moisture, the 1931 rains had the great duty of renewing the lakes and ponds and streams and providing subsurface storage for later needs, a duty that has been performed with fair devotion, though many streams remain at low stage, which adds importance to the rather general rains that have been falling up to this time in August. It looks as if Missouri and other States will start the fall and winter with the effects of the great drought of 1930 fully subdued. Surface water that has not flowed into the streams and thus to the seas has been taken up by famished earth many feet below the surface. We have been storing for future crops.

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SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS DURING AUGUST, 1931

By HERBERT H. KIMBALL, In Charge Solar Radiation Investigations

For a description of instruments employed and their exposures, the reader is referred to the January, 1931, REVIEW, page 41.

Table 1 shows that solar radiation intensities at Washington averaged below the normal values for August, and that at Madison and Lincoln they were above the normal.

Table 2 shows an excess in the total solar radiation received on a horizontal surface at Lincoln and Chicago, close to the August average at Madison, New York, and Fresno, and a deficiency at Washington, Pittsburgh, Twin Falls, and La Jolla.

Skylight polarization measurements made on 2 days at Washington gave 54 for the percentage of polarization, which is slightly below the August average. At Madison, polarization measurements made on 6 days give a mean of 62 per cent with a maximum of 70 per cent on the 11th, which are close to the corresponding averages for Madison in August.

A CHANGE IN WEEKLY AVERAGES FOR DAILY TOTALS OF SOLAR RADIATION AT FRESNO, CALIF.

Difficulty was experienced in standardizing the Moll pyrheliometer recording on an Engelhard microammeter at the time it was installed at Fresno, Calif., in October, 1928. In July, 1931, this pyrheliometer was received back at the central office in Washington, exposed beside an Eppley thermoelectric pyrheliometer, and the records from the two compared. The results show that the reduction factor determined at Fresno in 1928 was too high, the ratio of the new to the old factor being 0.94. Therefore, all pyrheliometer records for Fresno, Calif., obtained previous to July 23, 1931, the date when a new instrument was installed, should be multiplied by 0.94. Weekly means for Fresno heretofore in use have been so reduced.

TABLE 1.—*Solar radiation intensities during August, 1931*

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	8 a.m. / 75th mer. time (e.)	78.7° / 5.0	75.7° / 4.0	70.7° / 3.0	60.0° / 2.0	0.0° / 1.0	60.0° / 2.0	70.7° / 3.0	75.7° / 4.0	78.7° / 5.0	Noon / Local mean solar time (e.)
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Aug. 6	19.23			0.51	0.77						15.11
Aug. 7	17.37		0.51	0.64	0.87						15.11
Aug. 17	15.65			0.67	0.89	1.21					11.81
Aug. 24	10.97				1.11	1.36					10.59
Aug. 31	14.10		0.50	0.68	0.92	1.39					12.24
Means			(0.50)	0.62	0.91	1.32					
Departures			−0.16	−0.13	−0.01	+0.10					

Madison, Wis.

Date	e.	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	5.0	e.
Aug. 3	11.81		0.79								12.68
Aug. 4	15.11				1.25						12.24
Aug. 5	14.60				0.97						14.10
Aug. 6	18.59		0.50	0.55	0.82						15.11
Aug. 10	10.21				1.19						9.83
Aug. 11	8.81	0.80	0.88	1.01	1.21	1.46	1.21				7.29
Aug. 13	10.21			0.96	1.17	1.35					6.50
Aug. 21	8.81		0.90	1.07	1.20	1.40	1.13				7.29
Aug. 28	10.59			1.08	1.17						7.87
Aug. 29	7.04			1.08	1.22	1.42					6.02
Means		(0.80)	0.77	0.96	1.12	1.38	(1.17)				
Departures		+0.05	−0.06	+0.03	+0.03	+0.07	+0.10				

Lincoln, Nebr.

Date	e.	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	5.0	e.
Aug. 3	14.10	0.71	0.84	0.96	1.13	1.34	1.13	0.93	0.79	0.65	15.11
Aug. 4	16.79		0.82	0.93	1.09						14.60
Aug. 10	9.83	0.86	0.99	1.12	1.25	1.41					9.14
Aug. 11	9.83				1.26	1.46					12.68
Aug. 19	13.13						1.09	0.90	0.75	0.65	15.65
Aug. 22	10.21		0.74	0.89	1.07	1.30	1.08	0.89			11.38
Aug. 28	7.04					1.17					6.27
Means		(0.78)	(0.85)	0.98	1.16	1.38	1.12	0.91	(0.77)	(0.65)	
Departures		+0.11	+0.07	+0.08	+0.08	+0.08	+0.05	+0.02	+0.02	−0.04	

[1] Extrapolated.

TABLE 2.—*Total solar radiation (direct+diffuse) received on a horizontal surface*

[Gram-calories per square centimeter]

AVERAGE DAILY TOTALS

1931	Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Pittsburgh	Gainesville	Fresno	La Jolla	Miami	New Orleans
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
July 30	460	461	526	422	386	514	462		360	633		347
Aug. 6	410	447	468	340	283	528	336		614	305	573	431
Aug. 13	423	465	549	372	315	464	397	530	637	296	530	298
Aug. 20	265	455	534	408	309	513	275	424	597	401	570	269
Aug. 27	392	390	495	300	378	498	322	435	468	287	528	367

DEPARTURES FROM WEEKLY NORMALS

	Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Pittsburgh	Gainesville	Fresno	La Jolla	Miami	New Orleans
July 30	+5	−2	+4	+52	+18	−86	−7		+29	−32		
Aug. 6	−25	−12	−22	−16	−63	−69	−66		−87	−59		
Aug. 13	−5	+23	+60	+10	−9	−32	+48	+43	+41	−89		
Aug. 20	−139	+19	+41	+45	−1	−64	−28	−43	+29	−13		
Aug. 27	−23	−17	+38	−44	+65	−56	+20	+12	−74	−110		
Accumulated departures on Sept. 2, 1931	−44	+3,115	+770	−840	−1,190	−3,212	−2,094		−140	−6993		

POSITIONS AND AREAS OF SUN-SPOTS

[Communicated by Capt. J. F. Hellweg, Superintendent United States Naval Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, Perkins, and Mount Wilson observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column.]

Date	Eastern standard civil time (h m)	Heliographic Diff. long.	Heliographic Longitude	Heliographic Latitude	Area Spot	Area Group	Total area for each day
1931							
Aug. 1 (Naval Observatory)	10 56	+2.0	78.2	+7.5		46	
		+9.0	85.2	−6.5		62	108
Aug. 2 (Perkins Observatory)	10 37	−50.0	13.1	+5.0		117	
		−3.0	60.1	+20.0		93	
		+9.0	72.1	+23.0		70	
		+17.5	80.6	+4.5	40		
		+19.5	82.1	+20.0		62	382
Aug. 3 (Naval Observatory)	10 39	−38.0	11.9	+4.0		31	
		+22.0	71.9	−9.0		93	
		+27.0	76.9	+8.0		46	
		+39.0	88.9	−7.5	6		
		+55.0	104.9	−18.0	6		182
Aug. 4 (Naval Observatory)	10 37	−26.0	10.7	+5.0	31		
		+2.0	38.7	−18.0	3		
		+37.0	73.7	−10.0		62	
		+45.0	81.7	+7.0	12		
		+50.0	86.7	−7.5	6		114
Aug. 5 (Naval Observatory)	11 18	+50.5	73.6	−9.5		93	93
Aug. 6 (Naval Observatory)	10 41	−62.0	308.2	−7.0		31	
		+3.0	13.2	+10.5	9		
		+62.0	72.2	−9.5		62	102
Aug. 7 (Naval Observatory)	10 41	+79.0	76.0	−10.0		62	62
Aug. 8 (Naval Observatory)	10 37	+58.0	41.8	−22.0	6		6
Aug. 9 (Naval Observatory)	10 35	No spots					
Aug. 10 (Naval Observatory)	10 43	No spots					
Aug. 11 (Mount Wilson)	18 20	+44.0	343.9	+3.0	5		5
Aug. 12 (Yerkes Observatory)	15 6	No spots					
Aug. 13 (Naval Observatory)	12 38	No spots					
Aug. 14 (Mount Wilson)	17 0	No spots					
Aug. 15 (Naval Observatory)	12 2	−62.0	188.5	+10.0	9		
		−49.5	201.0	−19.0	6		
		−36.0	214.5	−8.0	6		21
Aug. 16 (Naval Observatory)	10 44	+1.0	239.0	−11.5	9		9
Aug. 17 (Naval Observatory)	10 44	+15.0	239.8	−11.0		93	93
Aug. 18 (Naval Observatory)	10 44	+28.5	240.0	−10.5		93	93
Aug. 19 (Yerkes Observatory)	14 20	+41.6	237.9	−10.6	21		
		+42.9	239.2	−10.2	2		
		+46.3	242.7	−9.6	6		
		+47.4	243.8	−10.1	6		
		+48.6	244.9	−9.6	3		
		+49.2	245.5	−10.8	12		50
Aug. 20 (Yerkes Observatory)	12 55	+53.8	237.7	−10.5	20		
		+54.9	238.8	−11.1		14	
		+55.0	238.9	−10.3	6		
		+63.0	246.9	−9.9	18		58
Aug. 21 (Yerkes Observatory)	10 33	+66.1	238.1	−10.9	7		
		+66.9	238.9	−11.5	21		
		+67.1	239.1	−10.6	5		
		+75.7	247.7	−9.5	34		67
Aug. 22 (Perkins Observatory)	12 25	No spots					
Aug. 23 (Perkins Observatory)	10 55	No spots					
Aug. 24 (Naval Observatory)	10 45	No spots					
Aug. 25 (Naval Observatory)	10 40	−24.5	94.6	+3.0	15		15
Aug. 26 (Naval Observatory)	11 40	−80.0	25.3	+3.5	31		
		+38.0	143.3	−3.0	9		40
Aug. 27 (Naval Observatory)	11 9	−70.0	22.4	+3.0	46		
		−42.0	50.4	+1.0	3		
		+8.5	100.9	+4.0	15		
		+32.5	124.9	−1.0	6		
		+52.0	144.4	−3.5	3		73
Aug. 28 (Naval Observatory)	12 48	−55.0	23.3	+3.0	77		
		−36.0	42.3	−8.0	31		
		+8.0	86.3	+5.0	19		127
Aug. 29 (Naval Observatory)	11 26	−85.0	340.8	+4.5	15		
		−42.0	23.8	+3.0	62		
		−24.0	41.8	−9.0		19	
		+21.5	87.3	+4.5		15	111
Aug. 30 (Naval Observatory)	10 46	−79.0	334.0	+5.5	9		
		−69.0	344.0	+4.5	15		
		−29.0	24.0	+3.0	62		
		−10.5	42.5	−9.0		15	101
Aug. 31 (Naval Observatory)	10 46	−62.0	337.7	+6.0	6		
		−55.0	344.7	+4.5	6		
		−26.0	13.7	+11.0		93	
		−17.0	22.7	+3.0	31		136
Mean daily area for August							66

PROVISIONAL SUN-SPOT RELATIVE NUMBERS, AUGUST, 1931

[Data furnished through the courtesy of Prof. W. Brunner, Eidgen, Sternwarte, Zurich Switzerland]
(Dependent alone on observations at Zurich and its station at Arosa)

August, 1931	Relative numbers	August, 1931	Relative numbers	August, 1931	Relative numbers
1	aa 23	11	8	21	10
2	Mecc 35	12	0	22	0
3	34	13	8	23	
4	28	14	0	24	0
5	28	15	0	25	0
6	19	16	0	26	Mc 8
7	8	17	Mc 11	27	Mcd 26
8	0	18	14	28	36
9	0	19	14	29	25
10	0	20	10	30	24
				31	30

Mean, 29 days=13.8.

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group or spot through the central meridian.
c=New formation of a center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central zone.
d=Entrance of a large or average-sized center of activity on the east limb.

LATE REPORTS

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR JANUARY, 1931

[Data furnished through the courtesy of Prof. W. Brunner, University of Zurich, Switzerland]
(Dependent alone on observations at Zurich and its station at Arosa)

January, 1931	Relative numbers	January, 1931	Relative numbers	January, 1931	Relative numbers
1	0	11	10	21	24
2	7	12	9	22	22
3	0	13	Mc 16	23	21
4	d __	14	41	24	
5	18	15	43	25	20
6	11	16	27	26	
7	11	17	Ec __	27	8
8	12	18	22	28	0
9	14	19		29	7
10	a 11	20	a 25	30	0
				31	

Mean: 25 days=15.2.

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group or spot through the central meridian.
c=New formation of a large or average-sized center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central zone.
d=Entrance of a large or average-sized center of activity on the east limb.

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR MAY, 1931

[Data furnished through the courtesy of Prof. W. Brunner, University of Zurich, Switzerland]

(Dependent alone on observations at Zurich and its station at Arosa)

May, 1931	Relative numbers	May, 1931	Relative numbers	May, 1931	Relative numbers
1	17	11	33	21	Ec 30
2	8	12	26	22	26
3	7	13	a 32	23	35
4	8	14	17	24	32
5	8	15	Ec 36	25	31
6	17	16	37	26	Wc 35
7	d 17	17	29	27	35
8	26	18		28	20
9	Mc 20	19	34	29	19
10	33	20	b __	30	d 20
				31	11?

Mean: 29 days=24.1.

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group or spot through the central meridian.
c=New formation of a center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central zone.
d=Entrance of a large or average-sized center of activity on the east limb.

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR JUNE, 1931

[Data furnished through the courtesy of Prof. W. Brunner, University of Zurich, Switzerland]

(Dependent alone on observations at Zurich and its station at Arosa)

June, 1931	Relative numbers	June, 1931	Relative numbers	June, 1931	Relative numbers
1	13	11	20	21	0
2	Ec 28	12	14	22	7
3	34	13	0	23	0
4	36	14	Wc 10	24	0
5	a 30	15	0	25	0
6	36	16	0	26	0
7	32	17	0	27	Ec 8
8	Mc 44	18	7	28	10
9	35	19	0	29	d 25
10	47	20	0	30	23

Mean: 30 days=15.3.

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group or spot through the central meridian.
c=New formation of a center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central zone.
d=Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[The Aerological Division, W. R. Gregg, in Charge]

By L. T. Samuels

In Table 1 are given the mean free-air temperatures and relative humidities for August for two kite stations, four Weather Bureau airplane stations, and four Navy airplane stations. Normal values are not available for all of these stations, but in most cases they have been determined for some near-by place. A comparison of these with the monthly means indicates small departures at the upper levels in most cases.

An interesting feature of Table 1 is the relatively low temperatures at the upper levels over Chicago as compared with those over Omaha. In this connection it is noted that the resultant free-air winds for the month contained an appreciably greater northerly component over Chicago than over Omaha. (See Table 2.)

At the 1,000-meter level the highest resultant winds occurred over southern Plains States, where they reached 9 meters per second with a strong southerly component. At 4,000 meters the resultant direction over this region was diametrically opposite with considerably lower velocities. Strong southerly components occurred at 6,000 meters over the extreme southern stations.

From Table 3 it will be seen that airplane observations were made on every scheduled day during the month, the maximum height being 7,242 meters, reached at Omaha on the 23d.

TABLE 1.—Mean free-air temperatures and humidities obtained by airplanes (or kites) during August, 1931

TEMPERATURE (°C.)

Altitude (meters) m. s. l.	Chicago, Ill.[1] (190 meters)	Cleveland, Ohio[1] (245 meters)	Dallas, Tex.[2] (140 meters)	Due West, S. C.[2] (217 meters)	Ellendale, N. Dak.[1] (444 meters)	Hampton Roads, Va.[3] (2 meters)	Omaha, Nebr.[1] (299 meters)	Pensacola, Fla.[3] (2 meters)	San Diego, Calif.[3] (9 meters)	Washington, D. C.[3] (2 meters)
Surface	18.0	17.7	23.0	23.7	18.4	25.2	17.7	24.2	23.9	22.4
500	19.3	18.8	23.5	21.9	18.2	22.8	18.5	24.0	20.6	21.8
1,000	18.5	18.3	22.7	19.5	17.0	20.6	19.5	20.5	22.8	20.2
1,500	15.5	15.3	20.3	16.3	15.2		17.4			
2,000	12.0	12.2	17.1	13.1	12.5	13.6	14.8	14.2	19.3	14.7
2,500	9.2	9.3	14.0	9.7	9.6		11.7			
3,000	6.4	6.6	10.9	6.6	6.8	7.4	8.8	8.8	12.2	8.6
4,000	0.4	1.6	5.3	0.0	0.9		2.2			3.2
5,000	−5.7	−3.4	−1.3				−4.5			
6,000		−8.4	−7.8				−11.8			
7,000							−19.5			

RELATIVE HUMIDITY (PER CENT)

Altitude (meters) m. s. l.	Chicago	Cleveland	Dallas	Due West	Ellendale	Hampton Roads	Omaha	Pensacola	San Diego	Washington
Surface	85	86	75	80	70	76	83	86	76	81
500	70	74	72	77	69	67	76	75	82	72
1,000	62	66	66	73	60	63	62	74	57	67
1,500	66	70	62	75	56		60			
2,000	68	72	62	73	56	66	56	60	52	70
2,500	58	66	63	72	57		53			
3,000	53	64	62	69	57	67	50	61	52	62
4,000	45	51	50	69	49		47			66
5,000	39	44	44				46			
6,000		36	41				44			
7,000							47			

[1] Airplanes (Weather Bureau). [2] Kites. [3] Airplanes (Navy).

TABLE 2.—Free-air resultant winds (meters per second) based on pilot-balloon observations made near 7 a. m. (E. S. T.) during August, 1931

Altitude (meters) m. s. l.	Albuquerque, N. Mex. (1,528 m) Direction	Velocity	Brownsville, Tex. (12 m) Direction	Velocity	Burlington, Vt. (132 m) Direction	Velocity	Cheyenne, Wyo. (1,873 m) Direction	Velocity	Chicago, Ill. (198 m) Direction	Velocity	Cleveland, Ohio (245 m) Direction	Velocity	Dallas, Tex. (154 m) Direction	Velocity	Due West, S. C. (217 m) Direction	Velocity	Ellendale, N. Dak. (444 m) Direction	Velocity	Havre, Mont. (762 m) Direction	Velocity	Jacksonville, Fla. (14 m) Direction	Velocity	Key West, Fla. (11 m) Direction	Velocity
Surface	N 47 E	0.6	S 37 E	0.6	S 6 E	1.7	N 70 W	2.8	S 89 W	0.8	S 6 W	1.2	S 36 E	1.7	N 61 W	0.2	N 68 W	1.3	S 72 W	0.7	S 55 W	0.6	S 78 E	2.3
500			S 13 E	7.1	S 48 W	1.8			N 79 W	2.2	S 77 W	2.2	S 6 W	7.1	N 64 W	2.2	N 84 W	1.0			S 71 W	2.6	S 72 E	5.6
1,000			S 12 E	7.5	N 67 W	3.1			N 63 W	2.8	N 75 W	3.2	S 32 W	7.3	N 80 W	3.0	S 65 W	3.3	S 87 W	1.9	S 80 W	2.4	S 69 E	5.3
1,500			S 16 E	6.0	N 58 W	4.3			N 67 W	3.7	N 80 W	3.6	S 35 W	4.8	S 88 W	3.7	S 87 W	4.1	N 80 W	3.2	S 79 W	2.2	S 75 E	3.8
2,000	S 17 E	1.3	S 26 E	5.4	N 57 W	5.2	N 81 W	3.8	N 73 W	4.1	N 74 W	4.5	S 53 W	2.9	S 76 W	4.6	N 80 W	5.3	N 84 W	5.4	S 82 W	2.0	S 80 E	2.8
2,500	S 25 W	1.4	S 30 E	4.5	N 66 W	6.0	S 76 W	3.4	N 48 W	3.5	N 65 W	4.9	N 40 W	2.5	S 81 W	5.4	N 70 W	7.6	N 88 W	6.5	S 66 W	2.8	S 74 E	2.8
3,000	S 61 W	1.4	S 41 E	2.4	N 63 W	7.3	S 86 W	3.4	N 34 W	3.9	N 73 W	5.3	N 10 W	3.5	N 70 W	7.6	N 75 W	8.2	S 88 W	6.7	S 75 W	3.4	S 79 E	3.0
4,000	N 31 W	0.5	S 22 E	0.8	N 73 W	6.1	N 70 W	4.2	N	5.2	N 37 W	3.0	N 13 E	5.0	N 75 W	8.2	N 66 W	7.9	N 88 W	8.8	S 67 W	3.7	S 50 E	3.3
5,000	N 16 E	1.9					N 54 W	3.8			N 4 E	4.9			N 84 W	6.0	S 77 W	6.0	N 89 W	10.8	S 13 W	2.6	S 60 E	2.6

Altitude (meters) m. s. l.	Los Angeles, Calif. (127 m) Direction	Velocity	Medford, Oreg. (410 m) Direction	Velocity	Memphis, Tenn. (145 m) Direction	Velocity	New Orleans, La. (25 m) Direction	Velocity	Oakland, Calif. (8 m) Direction	Velocity	Oklahoma City, Okla. (392 m) Direction	Velocity	Omaha, Nebr. (299 m) Direction	Velocity	Phoenix, Ariz. (356 m) Direction	Velocity	Salt Lake City, Utah (1,294 m) Direction	Velocity	Sault Ste. Marie, Mich. (198 m) Direction	Velocity	Seattle, Wash. (14 m) Direction	Velocity	Washington, D. C. (10 m) Direction	Velocity
Surface	S 75 E	0.1	S 34 W	0.4	S 18 W	1.4	N 62 E	0.4	N 75 W	0.9	S 5 E	2.1	S 22 E	1.4	S 73 E	2.5	S 87 E	3.1	N 87 E	0.5	S 32 E	0.8	N 2 E	0.7
500	S 78 E	1.0	S 84 W	0.8	S 57 W	4.4	S 9 E	0.4	S 60 W	2.0	S 7 W	4.9	S 4 W	3.5	S 67 E	3.1			S 50 E	1.7	N 25 E	1.0	N 12 W	3.3
1,000	N 64 E	0.6	N 66 W	1.2	S 75 W	4.7	S 22 W	1.0	N 83 W	2.9	S 31 W	9.2	S 34 W	5.2	S 57 E	1.6		0.7	S 79 W	1.8	N 13 E	2.6	N 32 W	2.8
1,500	S 24 W	0.6	N 87 E	0.6	S 88 W	4.4	S 20 W	1.8	S 78 W	3.0	S 53 W	5.5	S 72 W	4.2			S 30 E	4.8	N 82 W	3.1	N 6 W	2.6	N 48 W	4.6
2,000	S 18 E	1.7	S 26 E	0.8	N 59 W	2.3	S 39 W	1.4	S 48 W	3.8	S 76 W	2.1	N 85 W	3.9	S 51 E	0.2	S 1 W	4.3	N 71 W	4.4	N 35 W	1.4	N 60 W	5.3
2,500	S 27 E	3.5	S 31 W	3.2	N 43 W	2.8	S 53 W	1.8	S 37 W	5.2	N 41 W	2.7	N 62 W	4.3	S 25 E	0.9	S 33 W	2.5	N 54 W	4.7	N 59 W	1.6	N 67 W	5.2
3,000	S 30 E	5.4	S 32 W	5.4	N 36 W	2.6	S 70 W	2.2	S 44 W	7.0	N 14 W	2.8	N 33 W	3.8	S 49 E	3.5	S 64 W	3.1	N 35 W	5.3	N 55 W	4.2	N 70 W	6.7
4,000	S 45 E	3.3	S 44 W	8.1			N 89 W	2.3			N 18 W	2.3	N 35 W	4.8			S 73 W	5.1	N 19 E	4.8			N 60 W	5.1
5,000							N 79 W	2.4					N 10 E	5.5			S 66 W	8.3	N 11 E	4.8				

TABLE 3.—Observations by means of airplanes, kites, captive and limited-height sounding balloons during August, 1931

	Dallas, Tex.[1]	Due West, S. C.	Ellendale, N. Dak.	Chicago, Ill.[1]	Cleveland, Ohio[1]	Omaha, Nebr.[1,2]
Mean altitudes (meters), m. s. l., reached during month	5,898	2,590	3,337	5,101	5,785	6,248
Maximum altitude (meters), m. s. l., reached	6,304	4,450	[3]4,712	5,692	6,283	7,242
Number of flights made	31	26	32	31	31	24
Number of days on which flights were made	31	25	31	31	31	24

[1] Airplanes.
[2] Observations began Aug. 8.
[3] Limited-height sounding-balloon observation.

WEATHER IN THE UNITED STATES

THE WEATHER ELEMENTS

[Climatological Division, OLIVER L. FASSIG, in Charge]

By M. C. BENNETT

GENERAL SUMMARY

August, considering both temperature and precipitation for the whole country, was nearer a normal month than has been experienced for a long time. East of the Rocky Mountains the mean monthly temperature ranged generally but a degree or two above or below the normal, the Southern States being slightly below and the North slightly above the seasonal average. However, west of the Rocky Mountains the weather was generally warmer than the normal, while in the central portions of California the month was the hottest August of record.

Precipitation was above normal in the Atlantic States and considerable portions of the central Mississippi Valley and the far Southwest, while in the Great Plains area from western Kansas northward the precipitation was markedly deficient in some sections; large parts of South Dakota and Montana received less than one-fourth the normal, while much of the Pacific Northwest had practically a rainless month.

TEMPERATURE

The first decade was considerably hotter than normal from the middle Plains and the upper Mississippi Valley eastward to the middle Atlantic and New England coasts. Likewise the interior of the North Pacific States had some very hot days at this time, but most portions of Montana and North Dakota were cooler than normal. During the second decade and the first few days of the last decade most of the country from New Mexico and the middle Plains eastward was cooler than normal, the deficiency being quite marked in the lower Mississippi Valley; but during this period substantially all northern districts and practically all the country west of the Continental Divide were hotter than normal, the excess in Montana being about 8° per day.

The closing week of August brought a marked change in Minnesota, Wisconsin, and Michigan, where unseasonably cool weather prevailed. Most of the eastern half of the country likewise was cooler than normal, except the immediate Atlantic coast. The western half was hotter than normal, especially Nevada and central and southern California.

In every State August averaged within about 3° of normal, this being the first month since October, 1929, to be so close to normal throughout the Nation. Almost all northern and far western districts averaged warmer than normal, the excess being 2° to 3° or slightly more in a great part of the Lake region, and in most of Utah, Nevada, and eastern Oregon, and the northeastern, central, and southwestern portions of California. At several coast stations in California from San Francisco southward, also at Fresno, in the San Joaquin Valley, the month was the hottest August of record.

From New Mexico and western Kansas eastward to the south Atlantic coast the temperature averaged almost everywhere a little below normal, the greatest deficiency, about 3° a day, occurring in Arkansas and parts of the States adjoining.

The highest temperatures in the various States were 100° or more, save in New England, but were practically nowhere above 105° in the eastern half of the country. In the western half almost all States recorded 107° or higher, the very highest mark reported being 123° in southeastern California. In the eastern half the highest marks were noted during the first 10 days, but there was less uniformity in the West, though most of the Southwest noted the highest readings between the 18th and the 28th.

In a few Gulf and South Atlantic States which lack high mountains no reading lower than 50° was reported. In most States east of the Rocky Mountains the lowest marks were between 50° and freezing, but in Michigan, Wisconsin, and Minnesota several stations had temperatures considerably below freezing as the month ended, Wolverine, Mich., noting 24°. Temperatures about as low, or even lower, occurred at lofty stations in many far western States, the lowest of all being 17° in Colorado. The dates of lowest temperatures were largely within 10 days of the close of August, though in the central valleys and to southward and southeastward they were frequently noted about the 13th.

PRECIPITATION

The rainfall of August was fairly well distributed in point of time. From the middle and northern portions of the Rocky Mountain region eastward to the western part of the Lake region and the lower Ohio Valley there were widespread rains of importance during the first decade, and the portion of this area lying east of the Missouri River again had considerable rainfall during the final week. In the Atlantic and Gulf States the chief rains came between the 6th and the 24th. There was important rainfall in the far Southwest between the 3d and the 7th, then again during the very last days of the month.

The geographical distribution of the August rains was apparently better than usual in summer, though in many cases there were marked differences in amounts within short distances; yet, as far as reported, every station east of the Mississippi River and south of the Ohio and the southern limit of New York measured at least an inch during the month. The State average amounts were at least 2 inches everywhere east of the Rocky Mountain States, save in South Dakota and Michigan, where they were slightly less.

Within this area east of the Rocky Mountain States only the two States just named and Vermont failed to average 80 per cent of normal, and these three had about two-thirds of normal. No States here averaged more than 140 per cent of normal except a few in the upper Ohio Valley and the southern part of the middle Atlantic area. In general there was moderately more than normal in southern New England, North Carolina, Tennessee, and the central valleys. From western Kansas to northwestern and central Texas there was a moderate to considerable shortage.

In the far West conditions varied widely. The districts close to the Mexican border usually had much more rainfall than normal, and there was an excess in most of Nevada, northern Utah, southern Wyoming, and northeastern Colorado. A considerable deficiency was noted in Montana and northern Wyoming and everywhere to westward, practically no rain whatever falling in Oregon, western Idaho, or southeastern Washington.

The greatest monthly amount reported by a station in the United States proper was 15.73 inches, at Red

Springs, N. C. In the central part of the country Eureka Springs, Ark., led, with 14.67 inches, and in the far West, Helvetia, Ariz., with 11.27 inches.

SUNSHINE AND RELATIVE HUMIDITY

More than the average amount of sunshine was received in the central and northern plateau and Pacific coast regions, while much less than the normal amount for August was received in the central and southern portions of California, the southern plateau region, and in the far Southwest generally. Elsewhere sunshine was near the average, but slightly above in the Great Plains and slightly below in the East generally. The relative humidity was above the normal in the far Southwest, the north Pacific region, the central Mississippi and Ohio Valleys, and the Northern and Central Atlantic States. However, in all cases the averages were but slightly above the normal. Elsewhere the humidity was generally below the average, with minus departures rather pronounced in portions of the upper Mississippi and the Missouri Valleys and the northern Rocky Mountain region.

SEVERE LOCAL STORMS, AUGUST, 1931

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path yards[1]	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Woodburn, Iowa (northwest of)	1	3 p. m.	33		$500	Tornado	Corn and haystacks damaged; path 1 mile long	Official, U. S. Weather Bureau.
Greenfield (near), Iowa	1	6 p. m.			5,250	...do	Buildings and crops damaged	Do.
Mahaska County, Iowa	1				1,000	Wind squall	Trees uprooted; corn and fences leveled; telephone communication interrupted.	Do.
Johnstown, Pa.	2	5:15 – 7:20 p. m.			125,000	Hail and rain	3 small bridges washed away; many basements flooded; 4 persons injured.	Do.
Prairieton (near), Ind.	2					Wind and rain	Sheds, barns and crops damaged; many trees blown down.	Do.
Overbrook (near), Kans.	3	7:09 p. m.	30			Small tornado	Minor damage to a few buildings; corn injured; path 1.5 miles long.	Do.
Saratoga Springs, Glens Falls, and North Troy, N. Y.	3				200,000	Electrical and wind.	Hotel roof partially destroyed; damage to telephone, power lines and other property by falling trees.	Do.
Westport, Conn., and vicinity.	3			1	75,000	Electrical, wind, hail and rain.	Highways obstructed by fallen trees; wires blown down; windows and auto shields broken.	Hartford Times (Conn.).
Iuka, Kans., and vicinity	5	4:30 p. m.	880			Hail, rain and wind.	Injury chiefly to corn; power lines damaged; path 3 miles long.	Official, U. S. Weather Bureau.
Big Horn and Yellowstone Counties, Mont.	7				436,600	Hail	Much loss to buildings and crops; livestock killed.	Do.
Dallas County, Iowa	7	3 p. m.			1,700	Wind, squall	Telephone and trees damaged; plate glass broken.	Do.
San Elizario (near), Tex.	8	...do	2,640			Hail	Crops almost total loss.	Do.
Sturtevant, Wis.	8	5:15 p. m.			2,750	Wind, squall	Small farm buildings damaged corn lodged.	Do.
Bucyrus (near), Ohio	8				1,000	Wind	Farm buildings and trees damaged; crops hurt.	Do.
Philadelphia, Pa., and vicinity north of.	10	5-8 p. m.			100,000	Rain and electrical.	Damage chiefly by flooding of basements and subway.	Do.
Reading, Pa.	10	P. m.			50,000	...do	Mill partially destroyed; electric and telephone service crippled; crops leveled.	Do.
Between Woodfield and Etchison, Md.	10				5,000	Electrical	Large barn and contents destroyed.	Do.
Sheffield Lake Village, Ohio.	11	10:30 p. m.	16-34		50,000	Probably tornado.	Numerous cottages wrecked; overhead wires blown down; 10 persons injured.	Do.
Remsenburg, N. Y.	12	9 a. m.	10			Wind	Trees uprooted; several farm buildings damaged.	Do.
Salt Lake City, Utah, and vicinity.	13	P. m.			25,000	Heavy rain and wind.	Gravel pit equipment, railways, highways, residence and business properties damaged.	Do.
McClain and Garvin Counties, Okla.	16	4 p. m.	2 mi.		10,000	Hail	Damage confined to crops; path 8 miles long.	Do.
Denver, Fort Lupton, and Hudson, Colo.	16				151,500	...do	Extensive damage to crops and other property.	Do.
Polk County, Iowa	18	3 p. m.			3,000	...do	Farm property damaged.	Do.
Concordia, Kans. (10 miles northeast)	18	5:30 p. m.	100		3,000	Small tornado	Damage chiefly to small farm buildings; path 1 mile long.	Do.
Due West, S. C.	18		7			...do	Did not reach ground but crops directly under it were damaged.	Do.
Guthrie County, Iowa	19	4 p. m.	2 mi.			Wind and hail	Crops almost total loss in places; path 7 miles long.	Do.
Iowa County, Iowa	19				6,000	...do	Buildings and crops damaged.	Do.
Filmore County, Nebr.	20	3-4 p. m.	3 mi.		35,000	Hail and wind	Chief damage to crops; a few windmills and trees blown down; path 18 miles long.	Do.
New Braunfels (near), Tex.	20	8:25 p. m.			500	Tornado and hail.	Crops completely destroyed in small area; minor damage to buildings.	Do.
Richmond, Va.	20				20,000	Rain	Industrial plants flooded, walls, sidewalks, and pavements undermined; telephone service crippled.	Do.
Leesville (near), N. C.	21	3 p. m.			30,000	Wind and rain	Chief damage to crops.	Do.
Olton (near), Tex.	21	5 p. m.	2 mi.			Hail	Severe injury to crops; some stock loss.	Do.
Ione (near), N. Mex.	22	11 p. m.	2 mi.			...do	Considerable damage, character not reported.	Do.
Chesapeake Bay and Eastern Shore, Md.	22-23					Wind and rain	Corn flattened; tomatoes damaged; fruit blown off; wires broken; boats driven ashore.	Do.
York and Seward Counties, Nebr.	25	3-4 p. m.	3 mi.		20,000	Hail and wind	Much crop damage; poultry killed; path 20 miles long.	Do.
Centrahoma to Atoka, Okla.	25	4:30 p. m.	880-3,520		14,000	Hail	Crops damaged; path 20 miles long.	Do.
Jefferson County, Nebr.	25	4:30-5 p. m.			60,000	...do	Considerable crop loss.	Do.
Bryan County, Okla. (southwestern).	25	7 p. m.	1,760		26,000	...do	Crops damaged; path 9 miles long.	Do.
Frederick County, Md.	25					Hail and wind	Corn stripped; trees blown down.	Do.
Lenoir City, Tenn.	26				10,000	Electrical	Residence destroyed.	Do.
Cerro Gordo County, Iowa.	27	1-1:30 p. m.	25-34	1	160,000	Wind, hail, and tornado.	Pavilion, theater, numerous cottages and trees damaged or wrecked; crops injured; path 7 miles long; tornado near Clear Lake; 21 persons injured.	Do.
Fayette County, Iowa	27	3:30 p. m.				Wind, hail, and electrical.	Heavy crop loss; telephone service disrupted; 40 cows killed.	Do.
Buchanan County, Iowa	27	4 p. m.			10,000	Hail	Windows, roofs, and auto tops pierced; crops hurt; poultry killed.	Do.
Muscatine County, Iowa	27	5 p. m.	70		12,000	Wind and tornado	Tornado near Muscatine; damage on 3 farms; path 6 miles long.	Do.

[1] "Mi." signifies miles instead of yards.

SEVERE LOCAL STORMS, AUGUST, 1931—Continued

Place	Date	Time	Width of path yards [1]	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Bushton (near), Ill.	27	5 p. m.	2,640		13,000	Hail.	Crops and roofs damaged; glass broken; path 3 miles long.	Official, U. S. Weather Bureau.
Charleston, S. C. (north of).	27	6 p. m.			1,500	Thunderstorm and wind.	Damage to crops and outhouses.	Do.
Rock County northeastward to Lake Michigan, Wis.	27	7 p. m.				Thunderstorm and wind squalls.	Trees uprooted; poles and overhead wires blown down; corn lodged.	Do.
Chickasaw, Floyd, Scott, Wright, and Delaware Counties, Iowa.	27	P. m.				Wind and hail.	Crops, roofs, farm buildings and equipment, and trees damaged.	Do.
Delphi, Ind. (3 miles west).	27	do.			5,000	Small tornado.	Barn and several small buildings wrecked; trees blown down.	Do.
Linn and Jackson Counties, Iowa.	27	do.				Wind, rain and flood.	Sewers and cellars flooded; wires damaged; railway track and 8 bridges washed out.	Do.
Jo Daviess, Carroll, Lake, and Whiteside Counties, Ill.	27					Wind and electrical.	Number of buildings struck; barns burned; stock killed; wire services crippled; orchards hurt.	Do.
Norwich, Oneonta, and Goshen, N. Y.	27					Heavy rain.	Basements and low lands flooded.	Do.
Providence, R. I., and vicinity.	27–28					Thunderstorm.	12 houses struck by lightning; many telephones out of order.	Do.
Sparta, Ill., and vicinity.	28	2 a. m.	20–30		50,000	Probably tornado.	Roofs torn off; two-story brick building practically demolished; windows and walls pushed out.	Do.
Carlsbad (near), N. Mex.	28	4 p. m.	1,760		22,000	Hail.	Much cotton destroyed or damaged.	Do.
Emmitsburg, (near), Md.	28	P. m.			10,000	Thunderstorm and wind.	Garage and small buildings burned or wrecked; trees uprooted.	Do.
Yuma, Ariz.	29					Hail, wind, and rain.	Skylights, windows, and trees broken; small farm buildings demolished; cotton hurt.	Do.
Benton, Black Hawk, Carroll, Marshall, Story, and Monroe Counties, Iowa.	31	6:10 p. m.			44,000	Wind.	Buildings, crops, trees, and overhead wires damaged.	Do.
Riley County, Kans.	31	6:30 p. m.	6 mi.		50,000	Wind and hail.	Barn and pavilion wrecked; crops damaged; windows and light globes broken; roofs pierced; 1 person injured; path 7 miles long.	Do.
Volland to Maple Hill and Eskridge, Kans.	31	9:45 p. m.	2–10 mi.		25,000	do.	Windows broken; roofs and crops damaged; path 25 miles long.	Do.
Southeastern counties, Wis.	31	P. m.			12,000	Wind, squalls, thunderstorm, and hail.	Considerable damage to farm properties; tobacco injured.	Do.

[1] "Mi." signifies miles instead of yards.

RIVERS AND FLOODS

(River and Flood Division, Montrose W. Hayes in Charge)

By RICHMOND T. ZOCH

Important overflows occurred in the southeastern part of the country and in the Colorado River basin. The accompanying table of floods shows the crests reached.

Damage was reported as follows: In the Roanoke River system, $7,000; in the Neuse River system, $8,000; in the Cape Fear River system, $5,000; in the Peedee River system, $3,000; and in the Colorado River system, $3,000. The damage caused by high water in the Pearl River system was given in the July issue of the MONTHLY WEATHER REVIEW. There were no reports of losses received from the Tar or Santee River systems.

The value of property saved by warnings was, along the Roanoke River, $16,000; the Tar River, $1,000; the Neuse River, $6,000; the Cape Fear River, $8,000; and the Peedee River, $25,000.

Heavy local rains resulting in overflows in small streams, where it is impracticable to maintain a warning service, caused damage as follows: On August 1, $100,000 around Helena, Mont., and $50,000 around Sioux City, Iowa; and on August 13, $25,000 around Salt Lake City, Utah. Other overflows in small streams were reported, but the extent or amount of damage was not given.

Most of the rivers of the Mississippi system, except those in the Ohio basin, were at the lowest stages ever recorded in a summer month. Most of the rivers in California were also extremely low.

Table of flood stages in August, 1931

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC SLOPE DRAINAGE	Feet			Feet	
Roanoke:					
Randolph, Va.	21	23	24	21.4	24
Weldon, N. C.	30	24	25	34.1	25
Scotland Neck, N. C.	23	13	13	23.0	13
		24	26	25.2	26
Williamston, N. C.	9	13	19	9.8	18
		26	31	9.9	30
Fishing Creek: Enfield, N. C.	15	13	15	15.4	14
Tar: Rocky Mount, N. C.	9	13	13	9.2	13
Neuse:					
Neuse, N. C.	15	5	6	17.0	5
		1	2	14.5	2
Smithfield, N. C.	14	5	8	19.0	7
		12	17	16.8	13
		23	23	14.0	23
Cape Fear:					
Fayetteville, N. C.	35	23	24	36.2	23
Elizabethtown, N. C.	22	14	16	22.7	16
		22	26	29.0	24
Peedee:					
Cheraw, S. C.	27	22	23	30.0	23
Mars Bluff Bridge, S. C.	17	24	30	19.5	27
Poston, S. C.	18	29	31	18.9	30, 31
Santee: Rimini, S. C.	12	12	18	13.0	14, 15
		30	30	12.0	30
EAST GULF OF MEXICO DRAINAGE					
Pearl: Jackson, Miss.	20	[1] 29	10	26.4	5
GULF OF CALIFORNIA DRAINAGE					
Gila: Gila Bend, Ariz.	5	10	11	7.5	11
Colorado: Parker, Ariz.	7	6	6	9.5	6

[1] In July.

All dates are in August, unless otherwise indicated.

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

[By the Marine Division, W. F. McDonald, in charge]

NORTH ATLANTIC OCEAN

By W. F. McDonald

The normal pressure distribution over the Atlantic was considerably disturbed during August, 1931, especially in the latter half of the month. Extensive development of the usual Atlantic HIGH prevailed only during rather brief periods, comprising a few days at the beginning and end of the month and the interval between the 10th and 15th.

Even in this period, however, while high pressure conditions were dominant over most of the Atlantic, there was a storm development near the American coast, and the American steamship *Onondaga* encountered a gale of force 10, approaching New York from the southward on August 11. This disturbance did not show further development or progress, however, but diminished and disappeared within the next two days; but simultaneously with its disappearance there was development of a vigorous depression southeast of lower Greenland, which moved slowly southeastward deepening as it progressed. On the 13th the American steamship *Seattle Spirit*, bound from Bremen to Boston, ran into winds of gale force that culminated on the 14th in the strongest winds reported from any part of the Atlantic during the month (force 11), and this same disturbance moved over the British Isles with diminished intensity on the 17th, causing some damage by high winds and heavy rains.

A succession of slow-moving disturbances then began to cross the Atlantic, and it was not until the month was well along that the HIGH reestablished itself over the western part of the ocean, while there remained several sharp disturbances over the eastern portion of the main steamer routes. Considering the season, an unusual number of gales was reported between the 15th and 27th, with several ships encountering winds of force 10 in the eastern Atlantic. Press reports indicated that several passenger liners were diverted or slightly delayed in making their schedules.

The average pressure situation for the month as a whole (see Table 1) reflected this concentration of LOW movements across mid-ocean on paths more southerly than usual, in that averages were below normal over most of the area between 30° and 50° N. latitude, and above normal in surrounding areas, with the greatest excess lying to eastward of Greenland.

August was free from serious West Indian disturbances, although two very mild depressions were noted in the Caribbean Sea in the period from the 11th to the 17th. The first of these crossed the full length of the Caribbean from east to west, moved into Yucatan on the 16th, and passed near Frontera, Mexico, on the next day when the Honduran steamship *Morazan*, lying in port at Frontera, experienced a gale of force 9, together with a wind change characteristic of the central area of a tropical disturbance.

Fogs on the north Atlantic during August were confined, so far as our reports indicate, to areas north of latitude 40. They decreased greatly as compared with the previous month, being most extensive between the Grand Banks and the vicinity of Nantucket from the 7th to the 16th, with rather extensive fogginess still earlier in the month between the Grand Banks and the British Isles.

The reports indicate a great decrease in fogginess after the 17th with occurrence mainly in scattered banks and patches rather than in widespread blanketing of the steamer routes. It is worthy of note that the great reduction in fog appears to have been about coincident with the appearance of the series of disturbances noted above, which marked the disruption of the normal pressure distribution over the Atlantic.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, August, 1931*

Stations	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland [1]	29.98		30.32	20th	29.65	2d.
Reykjavik, Iceland [1]	29.94	0.13	30.32	29th	29.36	26th.
Lerwick, Shetland Isles [1]	29.95	0.15	30.36	29th	29.46	16th.
Valencia, Ireland [1]	29.90	−0.02	30.42	11th	28.95	16th.
Lisbon, Portugal [1]	30.06	0.04	30.36	22d	29.83	24th.
Madeira [1]	30.09	0.07	30.28	30th	29.96	4th.
Horta, Azores [1]	30.11	−0.09	30.31	1st	29.74	25th.
Belle Isle, Newfoundland [1]	29.94	0.05	30.30	13th	29.22	1st.
Halifax, Nova Scotia [1]	30.00	−0.01	30.36	14th	29.70	10th.
Nantucket [2]	30.01	0.02	30.40	14th	29.64	10th.
Hatteras [2]	30.04	0.04	30.32	15th	29.74	10th.
Bermuda [1]	30.13	−0.01	30.36	13th	30.00	6th.
Turks Island [1]	30.10	0.06	30.14	2d	30.02	7th.
Key West [2]	30.03	0.05	30.12	24th	29.92	14th.
New Orleans [2]	30.06	0.08	30.25	24th	29.80	10th.

[1] All data based on a. m. observations only, with departure computed from best available normals related to time of observation.
[2] Corrected 24-hour means, based on more than one observation daily.

OCEAN GALES AND STORMS, AUGUST, 1931

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° '	° '				*Inches*					
General Greene, Am. S. S.	St. Johns	Labrador	59 28 N	44 28 W	Aug. 1	11 p., 2	Aug. 2	29.00	NE	NE	N	ENE, 9	NE-N.
West Harcuvar, Am. S. S.	Bremen	Boston	53 30 N	39 52 W	Aug. 2	1 a., 2	do	29.46	SSW	SW, 7	SW	SW, 8	
Baron Kelvin, Br. S. S.	Cape Town	Calais	47 25 N	5 40 W	Aug. 8	8 a., 8	Aug. 9	29.47	NW	WNW, 8	WSW	NNW, 8	NW-W-NNW.
Onondaga, Am. S. S.	Canal Zone	New York	39 37 N	73 50 W	Aug. 11	6 p., 11	Aug. 12	29.69	NNE	NNE	N	NNE, 10	
Lustrous, Br. S. S.	Houston	Hamburg	47 22 N	33 00 W	Aug. 12	10 a., 12	do		SW	SW, 7	N	SW, 8	SW-N.
Seattle Spirit, Am. S. S.	Bremen	Boston	50 20 N	20 00 W	Aug. 13	8 a., 14	Aug. 15	29.03	NW	NW, 11	NNW	NW, 11	
Ohioan, Am. S. S.	New York	Los Angeles	15 15 N	76 10 W	do	4 a., 14	Aug. 14	29.86	E	E, 9	E	E, 9	
Lustrous, Br. S. S.	Houston	Hamburg	49 17 N	15 50 W	do	Noon, 15	Aug. 17		NW	WNW, 8	SW	WSW, 9	NW-W.
Boston City, Br. S. S.	Bristol	Wilmington	51 20 N	7 26 W	Aug. 15	8 a., 16	do	28.96	S	SSW, 8	WSW	SSW, 8	SSW-WSW.
New York, Gr. S. S.	Cherbourg	New York	49 45 N	12 00 W	do	4 p., 15	Aug. 15	28.85	SW	SW, 9	WNW	SW, 9	SSW-WSW.
Jason, Du. S. S.	Amsterdam	Canal Zone	47 01 N	9 19 W	do	do	Aug. 16	29.25	SW	WSW, 8		WSW, 8	WSW-WNW.
Berlin, Gr. S. S.	Bremerhaven	New York	49 53 N	10 54 W	do	12 mid., 15	do	29.16	SW	SW, 8	W	—, 9	S-W.
Morazan, Hon. S. S.	New Orleans	Mexico	18 38 N	92 44 W	Aug. 17	Mid., 17	Aug. 17	29.74	NW	NW, 8	S	NW, 9	NW-S.
Statendam, Du. S. S.	New York	Rotterdam	42 16 N	49 50 W	do	2 p., 18	Aug. 18	29.52	NNW	ESE, 5	S	ENE, 8	NE-E.

OCEAN GALES AND STORMS, AUGUST, 1931—Continued

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN—Continued			° ′	° ′				*Inches*					
Independence Hall, Am. S. S.	Bordeaux	New York	47 00 N	8 48 W	Aug. 19	8 a., 19	Aug. 20	29.52	W	WSW, —	WNW	WNW, 9	WSW-WNW.
De Grasse, Fr. S. S.	Plymouth	do	44 24 N	46 15 W	do	6 p., 19	do	29.78	SW	WSW, 6	WNW	WNW, 8	WSW-WNW.
Jean Jadot, Bel. S. S.	New York	Antwerp	44 23 N	43 35 W	do	4 p., 20	Aug. 21	29.67	WNW	W, 9	N	NNW, 9	W-NNW.
Brave Coeur, Am. S. S.	New Orleans	London	38 12 N	69 24 W	Aug. 22		Aug. 25	29.91	NE	NE, 7	SSW	E, 8	NE-SE-SSW.
Selma City, Am. S. S.	Canal Zone	Portsmouth	38 01 N	72 18 W	do	2 p., 22	Aug. 23	29.90	NE	NE, 8	NE	NE, 8	ENE-NE.
Binnendijk, Du. S. S.	Port Said	Boston	41 29 N	28 38 W	Aug. 24	6 a., 25	Aug. 25	29.41	S	S, 8	NW	N, 9	SSE-S-N.
Cerinthus, Br. S. S.	France	Port Arthur	40 36 N	27 32 W	do	9 a., 25	Aug. 26	29.40	SSE	SSW, 6	NNW	NNW, 8	SSW-NNW.
Middleham Castle, Br. S. S.	Antwerp	Corpus Christi.	49 30 N	4 45 W	do	10 p., 24	Aug. 25	29.25	SE	NE, 8	NNE	E, 9	SE-NNE.
Asia, Dan. T. S.	do	Cristobal	49 30 N	5 50 W	do	—, 24	do	29.20	E	ENE, 10	NE	ENE, 10	ESE-ENE.
Do	do	do	47 05 N	21 45 W	Aug. 25	—, 25	Aug. 27	29.12	SE	SE, 5	N	N, 10	S-SE-NW.
West Harshaw, Am. S. S.	London	New Orleans	42 55 N	22 45 W	do	Noon, 25	do	29.54	S	SSW, 9	WNW	SSW, 9	S-SW.
Barbadian, Br. S. S.	Liverpool	Bermuda	44 10 N	22 42 W	do	8 p., 25	do	29.00	SE	S, 7	N	W, 10	S-W.
Hybert, Am. S. S.	Bremen	Tampa	44 45 N	22 35 W	do	10 a., 26	do	29.04	SSE	SSW, 9	NW	SSW, 9	SSE-SW-NW.
Middleham Castle, Br. S. S.	Antwerp	Corpus Christi.	42 30 N	17 15 W	Aug. 26	4 p., 27	Aug. 28	29.71	SE	SW, 7	WNW	W, 8	SE-WNW.
Baron Kelvin, Br. S. S.	Swansea	Providence	50 20 N	26 52 W	do	Noon, 26	Aug. 27	29.79	E	NE, —	NNW	NE, 9	
France, Fr. S. S.	New York	Le Havre	49 10 N	22 19 W	do	6 a., 26	do	29.55	NNE	ENE, 7	E	ENE, 9	
NORTH PACIFIC OCEAN													
Liberator, Am. S. S.	Honolulu	Shanghai	30 14 N	129 25 E	Aug. 17	Noon, 17	Aug. 18	29.30	SE	SE, —	S	SE, 9	SE-S.
Tamaha, Br. S. S.	Shanghai	San Pedro	31 45 N	123 50 E	Aug. 24	4 p., 25	Aug. 27	29.30	NE	ESE, —	SW	S, 10	E-ESE.
San Diego Maru, Jap. M. S.	Yokohama	Los Angeles	43 14 N	173 40 W	Aug. 27	8 p., 27	Aug. 28	[1] 29.18	S	S, 8	WSW	SSW, 8	S-SW.
Atago Maru, Jap. M. S.	do	San Francisco	47 35 N	176 00 W	Aug. 29	2 p., 30	Aug. 31	28.91	SSE	SW, 8	W	SW, 9	
Brunswick, Pan. M. S.	Sydney, N. S. W	Los Angeles	18 33 N	143 22 W	Aug. 30	11 p., 30	do	[2] 28.82	NE	N, 11	SE	N, 11	N-NW-W.
SOUTH PACIFIC OCEAN													
Laurel, Swed. M. S.	San Pedro	Port Lyttelton.	36 50 S	177 10 W	Aug. 1	8 p., 1	Aug. 2	[2] 29.46	WNW	W, 10	WSW	W, 10	Steady.
Golden Eagle, Am. S. S.	Los Angeles	Melbourne	21 14 S	179 38 W	Aug. 4	11 p., 4	Aug. 6	29.76	SE	SE, 8	SE	SE, 9	
Do	do	do	36 46 S	152 51 E	Aug. 13	9 p., 13	Aug. 14	29.88	N	NNW, 7	NW	NNW, 8	NNW-NW.
INDIAN OCEAN													
Fairfield City, Am. S. S.	Manila	Aden	11 55 N	52 45 E	Aug. 6	4 p., 10	Aug. 10	29.56	SW	WSW, 8	SW	SW, 10	

[1] Barometer uncorrected.　　　　　[2] Barometer reading approximate.

NORTH PACIFIC OCEAN

By WILLIS E. HURD

Atmospheric pressure.—The north Pacific anticyclone was the controlling factor of the weather during the greater part of August, 1931, over most of the eastern half of the ocean. In the Aleutian and lower Alaskan region pressure for the most part continued little affected by cyclonic influences until after the 20th. About the 22d a tendency toward lower pressures was observed in northern waters, and on the last three days of the month a deep cyclone developed, the minimum barometer reading at Dutch Harbor being 28.82 inches, on the 30th. The average pressure at this station, however, as elsewhere among the northern islands and along the American coast, was above normal for August. At Midway Island the average for the month was below normal, and thence westward to the Asiatic coast pressure generally was comparatively low, owing to the prevalence of numerous cyclonic disturbances in the Far East.

The following table gives barometric data for several island and coast stations in west longitudes, including Point Barrow on the Arctic Ocean:

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean and adjacent waters, August, 1931, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrow [1][2]	29.99	+0.10	30.44	24th	29.70	13th.
Dutch Harbor [1]	29.97	+0.11	30.44	9th	28.82	30th.
St. Paul [1][2]	29.93	+0.15	30.28	8th	29.02	30th.
Kodiak [1][2]	29.92	+0.06	30.22	8th [4]	29.08	31st.
Midway Island [1]	29.99	−0.09	30.08	10th [4]	29.90	20th. [4]
Honolulu [5]	30.01	0.00	30.07	23d	29.90	16th.
Juneau [5]	30.05	+0.03	30.23	5th	29.66	31st.
Tatoosh Island [5][6]	30.10	+0.10	30.27	26th	29.86	9th.
San Francisco [5][6]	29.95	+0.03	30.12	14th	29.77	2d.
San Diego [5][6]	29.92	+0.03	30.04	31st	29.77	2d.

[1] P. m. observations in averages; a. m. and p. m. in extremes.
[2] For 29 days.
[3] For 30 days.
[4] And on other date or dates.
[5] A. m. and p. m. observations.
[6] Corrected to 24-hour mean.

Cyclones and gales.—The weather along the upper steamship routes during August may be described as having the inconvenience of low visibility and much fog, though few of

the dangers of high winds and accompanying rough seas. Indeed, it was not until the last decade of the month, or between the 22d and 30th, as gathered from numerous reports that winds of gale velocity actually occurred in the northern trans-Pacific latitudes. These included two days with gales of moderate force, a day with a fresh gale, and a fourth day with a wind of force 9, all occurring within the region 42° to 48° N., 175° E. to 170° W. This was during the period of revival of the Aleutian LOW.

Tropical storm activity was of marked importance in the weather of Asiatic waters for the first time since the beginning of the year. A full report on the several typhoons that occurred there, prepared by the Rev. Miguel Selga, S. J., of the Philippine Weather Bureau, appears elsewhere in this issue of the REVIEW, and the storms therefore need no further description. It may be added however, that the typhoon which entered the China coast on the 9th and 10th and continued far inland, was probably mainly responsible for the heavy rains which caused the serious flood conditions in the Yangtse River near Hankow. Conditions attending the later typhoons of the 17th to 18th and the 24th to 26th served to aggravate the flood situation and increase the sufferings of the many thousands of homeless and hungry Chinese.

An intense cyclone was experienced on the 30th and 31st in the southeastern Pacific by the Panaman motor ship *Brunswick*, Capt. P. A. Yorgensen, observer A. Gratningsater, Sydney to Los Angeles. Said the observer:

The storm started August 30 with increasing NE. wind. At noon 30th in 18° 00′ N., 143° 52′ W., barometer 29.63 (approximate), wind NE., 8. During day gradually increasing wind and sea. At 10.11 p. m., in 18° 33′ N., 143° 22′ W., barometer dropped rapidly to 28.94 (approx,) and was ranging between 28.94 and 28.82 for about 15 minutes, while wind shifted N.-NW.; later rising barometer with wind shifting to W., SW., and S., and finally settling down on SE., where it blew out during next 24 hours. The maximum wind was from N., force 11. Temperature over 80°. Weather hazy with rain.

This is the fifth tropical cyclone known to form thus near and to the eastward of the Hawaiian Islands in the last 22 years.

While no cyclones occurred this August off the west coast of Mexico, a moderate northwest gale was experienced on the 15th in the Gulf of Tehuantepec during the existence of a depression in the Gulf of Honduras, and a local gale occurred on the morning of the 19th during a flurry at the mouth of the Gulf of California. During a 3-hour electrical storm on the 11th in 8° 55′ N., 85° 07′ W., the American steamship *K. R. Kingsbury* was reported "struck by lightning six or seven times."

Winds at Honolulu.—The prevailing wind direction at Honolulu was east, with northeast as next in frequency. The maximum velocity was 24 miles from the northeast on the 6th.

Fog.—Along the northern routes fog was slightly less frequent as a whole than in July, but was still a factor of great importance, since it occurred on 20 to 50 per cent of the days over much of the ocean between about 42° and 52° N., to the westward of about 150° W. The region of maximum occurrence here was south of the central and western Aleutians. Off the American coast between central California and the mouth of the Columbia River there was more fog than in the previous month, with a maximum of approximately 15 days on which it was observed to the northward of Eureka. South of San Francisco fog decreased sharply in occurence to the central coast of Lower California, where reports of it ceased.

TYPHOONS OF AUGUST, 1931

By REV. MIGUEL SELGA, S. J.

[Weather Bureau, Manila, P. I.]

The first seven months of the year 1931 were unusually free from typhoons in the Philippines. The typhoon season having been delayed, there was in many regions a general complaint of lack of rain, which threatened to affect adversely the crop of rice. By the end of July the typhoon season had set in and the rains that in Manila had been 73 per cent below normal up to the end of July were 150 per cent above normal by the end of August.

The Pratas typhoon—July 29 to August 2, 1931.—The first certain indications of this typhoon are found in our weather maps of July 29, when the barometers began to fall gradually in the Philippines. The isobars of the 2 p. m., weather map of July 29 and the wind directions, which were northeast in northeastern Luzon, northwest in southern Luzon and Samar, westerly in southern Leyte, southern Samar and Surigao, south by west in Palau, and southeast in Yap, pointed to a center of a disturbance that was tentatively located within a hundred miles of 15° N. and 127° E.

On the afternoon of July 29 all ships were warned by radio, and Provinces of the islands were notified by telegraph that there was a depression over the Pacific three or four hundred miles east of Luzon. The barometric gradient at 6 a. m. on July 30 indicated that the center of the typhoon was to the east of Baler Bay. A convergence of cirrus toward the east-southeast observed at Basco at 6 a. m. is worth recording here. The usual drift of air at cirrus level in our latitudes is from the east and seems to act, as component force from the east, on the cirri radiated out from a typhoon center and at a considerable distance from the vortex. From an analysis of 37 former observations of cirrus directions in the front quadrants of typhoons, Mr. Leo G. Welch, S. J., of Manila Observatory, has found that in 19 cases the cirri were diverging exactly radially from the center, and in 15 cases the directions were less than 45° off from radial divergence, and that the lack of radial divergence could in every case be explained by a component force from the east. Three cases for unknown reasons are in apparent contradiction to the rule. Undoubtedly the convergence observed at Basco was due to the typhoon and could be taken as a fair precursory sign. All along the eastern coast of Luzon, as well as in Basco, the pressure had fallen 2 mm. from 6 a. m. of the 29th to 6 a. m. of the 30th. The center was plotted out to be near 16° 30′ N., 126° 10′ E., moving northwest by north. It continued in this direction until 2 p. m., when it was located at approximately 18° 50′ N., 125° E. Here it changed its course to west-northwest, due to a high pressure center over Japan which was increasing and causing the barometers to rise even in Oshima and Shanghai. Advancing in its westerly motion, the typhoon was at 6 p. m. in the center of the Balintang Channel, between Aparri and Basco.

A cablegram was dispatched to Hong Kong at 9 p. m. on July 30 to warn the colony of the sudden and dangerous turn of the typhoon. Maintaining its west-northwesterly course, the center of the typhoon passed over the Pratas shoal at 8:30 p. m., July 31, when the barometer of Pratas Observatory registered the minimum of 740.9 mm. The wind that at 5 p. m. was blowing from the north with force 7–8 dropped to a dead calm at 7:30 p. m. and remained absolutely still for two hours until 9:30 p. m.,

when it sprang from the south-southwest with force 8. In the three and a half hours immediately preceding the minimum, the barometer dropped 4.85 mm., but it gained 7.10 mm. in the two and a half hours following the barometric minimum.

Very early in the morning on August 1 precautions were taken in Hong Kong to minimize the effects of the typhoon that was threatening to strike the colony about noon. Ships sought safety in Typhoon Bay. The wind increased in force at 8 a. m. and from noon to 4 p. m. it was blowing a gale, while the typhoon was making its way to the continent between Hong Kong and Macao. The easterly gale of the afternoon blowing straight against the harbor of Hong Kong dashed the waves against the sea wall, sending volumes of spray into the air. The eastern end of Queen's Pier was badly damaged, big blocks of granite and concrete being flung into the harbor and on to the Praya. Due to the timely warnings issued by the Hong Kong Observatory, the colony escaped the blow fairly lightly. Typhoon signal No. 10 was hoisted in Hong Kong for the first time after the adoption of the new system of typhoon signals recommended by the Conference of Directors of Far Eastern Weather Services in 1930.

The Japanese steamer *Ryusei Maru* was reported in distress, having run into the center of the typhoon, 50 miles east-southeast of Hong Kong. The *President Jefferson* rode out the storm safely in Typhoon Bay, Hong Kong. Its wind veered from northeast, force 7, at 11 a. m. to southeast, force 4, at 7 p. m. Its lowest barometric reading was 743.4 mm. at noon; its strongest winds were from the east-northeast, force 11–12, at 1 p. m. Inland the typhoon weakened and seems to have filled up on August 2.

This typhoon increased in force of wind and depth of barometer from the Philippines to Hong Kong. It caused a very modest amount of rainfall, but no severe squalls, in the Philippines.

The Waishing-Kwongsang typhoon.—August 6–12, 1931. —From August 2 to 6 the weather of northern Luzon remained unsettled, with low barometer, light winds, and constant indications of shallow depressions. Our afternoon weather map of August 7 showed a typhoon at a considerable distance northeast of Aparri. It remained almost stationary or curved slowly until the afternoon of August 8, when it started off toward the north. On the afternoon of August 9, it appeared almost southeast of Ishigakijima. Pushed backward by the high pressure over Japan, the typhoon changed its course and headed off toward the northwest, passing very close to the northeast of Ishigakijima. The pressure at this station at 11 a. m. on August 9 had fallen to 739.5 mm., with north-north-west winds of force 6. Retaining its northwesterly direction, the typhoon passed 50 or 60 miles to the north of Keelung, Formosa, crossed the northern entrance of the Formosa Channel, raising mountainous seas and causing terrific winds, and entered the continent between Foochow and Wenchow in the morning of August 10. With a constantly increasing and gradual inclination to the west, the typhoon moved toward the interior of China for over 600 miles and seems to have filled up on August 12 in the Province of Kweichow.

Many ships were seriously affected by the strong winds and seas caused by this typhoon, especially along the China coast.

The *Susana II* rode out the storm in the harbor of Keelung while coaling. Her barometer dropped to 740.2

mm. on August 10 at 1 a. m., with winds from the west, force 5.

While the typhoon was crossing the northern entrance of the Formosa Channel the 5,000-ton steamer *Benarty* of the Ben Line was lashed by hurricane winds and pounded by mountainous seas for eight hours north of Swatow. "It was the worst experience of my life," said the master of the ship in reporting the terrific gale, with squalls often exceeding 100 miles an hour. The chief engineer was washed overboard by a huge wave; a lifeboat, being hurled over the side, was smashed to pieces by the power of the seas.

The 1,865-ton steamer *Waishing* of the Indo-China S. N. Co., bound from Hong Kong to Shanghai, encountered tremendous seas on August 10 after passing Foochow and, finding herself unable to battle against the elements, took refuge in Nam Kwan Bay, but, overtaken by the typhoon, the ship was driven ashore by the violence of the seas, was badly holed, and left in a precarious condition on the rocks. It is stated that the *Waishing* had hardly struck the rocks when pirates swarmed about, making off with everything they could lay their hands on. To prevent further pillage, and while waiting for the arrival of rescue ships in answer to the S O S calls, a perimeter camp had to be formed ashore, gathering the survivors on top of a small hillock and mounting guard with one revolver that had been salvaged from the wreck. One of the ships to answer the S O S call was the *Kwongsang*, of the same Indo-China S. N. Co., bound from Shanghai to Hong Kong. She seems to have been off Fu Island, just 30 miles of the Nam Kwan Bay, headed to the assistance of the *Waishing*, when she foundered after a furious battle against the typhoon. The *Kwongsang* carried 6 European officers and a crew of 56 Chinese. Bodies of many victims washed ashore, and stories of local fishermen of Fu Yan and Funingfu all point to the probability that no passenger escaped the disaster of *Kwongsang*.

Our own steamship *President Jefferson*, with many and prominent passengers on board, passed very close to the center of this typhoon on August 10 between Foochow and Wenchow and experienced winds of force 8 to 10 for over six hours.

The China Sea typhoon, August 7–20, 1931.—From August 7 to 12 a low-pressure area prevailed over the China Sea from northern Annam to Luzon. On the morning of August 13 it was evident that a well-defined center had developed in the trough of the low pressure, which had deepened considerably on the 12th. It had moved to the north of Macclesfield Bank by Friday afternoon and developed into a typhoon very early in the morning of August 15, moving north. The U. S. S. *Simpson*, laboring under heavy seas 60 miles west by south of Koshun, reported east-southeast winds of force 8 at 6 a. m. on August 15. The typhoon inclined to east-northeast, passed south and east of Pratas in the afternoon of August 15, and recurved to northwest at night approaching Bias Bay. The lowest barometric reading at Pratas was 739.80 mm. at 3 p. m. with winds from north-northeast and force 3, three hours previously the barometer read 742.09 mm., with east-northeast winds of force 6, while at 6 p. m. the wind had backed to southwest, force 4, with the barometer at 741.14 mm. For the 24 hours following August 16, 6 a. m., the typhoon moved slowly northward, passing by to the east of Hong Kong late on the night of the 16th. During the forenoon of the 17th it entered the coast of China, between Hong Kong

and Swatow. The wind at Gap Rock backed from east-northeast, force 6, at 5 p. m. on August 15, to north, force 6, at 10 p. m. and north-northwest, force 7, at 7 a. m. August 16, remaining steady from that direction until 3 a. m. August 17, increasing to force 8 at 11 a. m. August 17. Two days after the typhoon had entered China it filled up in the Provinces of Wangtung or Kiangsi.

This depression and typhoon will be memorable for the heavy rains it caused, the rough seas it excited in the China Sea, and the poor visibility it brought in.

A régime of intermittent squalls and abundant rainfall along the western coast of Luzon and in the Visaya Islands began with the typhoon preceding this one and with the low-pressure area over the China Sea out of which this typhoon developed. The winds freshened on August 7 and the following days brought squalls which were most severe at Baler, Maasin, Calbayog, Cebu, and Sorsogon. Strong winds were felt also at Batangas, Corregidor, Manila, and Baguio. Winds of force 7 were reported from Calbayog and Baler on August 10 and from Cebu on August 11, 13, and 15. Force 8 was reported from Calbayog on August 13 and 18. Many other stations reported squalls in which the wind reached force 6. A gale blowing over the China Sea built up high waves that persisted for several days. The U. S. S. *Simpson*, the U. S. S. *Chaumont*, the *Hanover*, the *Anking*, and the *Hinsang*, navigating the eastern part of the China Sea, reported very rough seas, with winds of force 6 to 8. The visibility all over the China Sea was so poor that masters of long experience in the navigation of these seas encountered considerable difficulty in making ports and sighting lighthouses. At the entrance of Corregidor the weather was so thick and the rain so blinding that one end of the ship could not be seen from the other.

The rainfall during this time was heaviest on the western coast of Luzon. Coming simultaneously with the highest tide ever experienced in Manila during the last 26 years, it caused floods in Manila and many low sections of near-by Provinces. The total rainfall in millimeters from August 7 to 15 was 579.9 in Batangas' 793.5 in Dagupan, 886.8 in Iba, and 1,036.5 in Manila. The floods of Manila and adjacent Provinces may afford occasion for another paper, when all the rainfall returns have been received.

The Pacific typhoon of August 11 to 18, 1931.—Almost simultaneously with the formation of the preceding typhoon another one was developing between the Caroline and Marianas Islands. Prescinding from its early indications shown in our weather maps from the 9th to the 11th, and omitting the uncertain movements of the typhoon up to August 14, it was not until the 15th that it had any perceptible effect on the stations in the Loochoos and Bonin Islands and could be definitely situated in about 24° latitude N. and 134° longitude E. It then moved almost west-northwest until the morning of August 16, when it inclined more to the west until the afternoon of the same day, taking afterwards a definite northwest movement until noon of the 17th. Inclining more to the west in the afternoon of August 17, it passed between Naha and Oshima over into the Eastern Sea, where it filled up.

Throughout its course this typhoon remained too far away from our archipelago to have any serious effect on our weather. As far as observations are available at present, nowhere did the barometer fall below 746 mm. under the influence of this typhoon, nor were gales experienced along its path.

The Naha Typhoon, August 14 to 28, 1931.—Probable indications of this typhoon appear in our weather maps of August 14 to 17. Originating between Guam and Yap, it moved very slowly to the north first, but it inclined to the west-northwest at 6 a. m. of the 19th. While swerving more and more to west during the next 48 hours, the barometric minimum deepened, and while the inflow of the air in front of the advancing cyclone was slight, southwesterly winds of force 4 to 6 prevailed from the Strait of San Bernardino down to the northern Mindanao. Under these conditions the U. S. Navy transport *Chaumont*, south of the storm, was fighting its way to Guam against winds of force 7. By this time the last spur of the Pacific high was receding further toward the Pacific, leaving the whole field of the Far East to the typhoon. From 6 a. m. of the 21st to 2 p. m. of the same day the typhoon moved northwest, but inclined successively north-northwest, north, north by east, and back to north until August 23. Changing its course rapidly to the west, the typhoon passed south of and very close to Naha early in the morning of August 24, causing the barometer of Naha to fall at least to 724 mm. Maintaining its westerly motion for 24 hours, the storm inclined to west-northwest, northwest, north-northwest, and north by west, heading for Shanghai.

On the evening of August 25, it struck Ningpo with the full force of a violent gale. After having crossed Hangchow Bay it inclined slightly north by east and instead of devastating Shanghai it passed east of and close to the city at about 3 a. m. on August 26. In the great commercial city, however, and along the Whangpoo River the winds were fierce, and squalls exceeded at times the velocity of 100 miles per hour. Hundreds of trees in the settlement were uprooted or broken. Untold damage was done to roof tops and frail buildings. Flood water piled high by the force of the wind passed the previous high-water record by half a foot and flooded the majority of downtown ground floors in the clubs, banks, and godowns. According to the chief engineer of the Whangpoo Conservancy Board, this excessive water level was due to strong typhoon conditions superimposed on a growing spring tide and the slight rise of the general water levels at Shanghai consequent upon the Yangtze floods. The extraordinary fact that no serious disaster occurred on the water front, in spite of the thousands of small craft and the absence of shelter for both large and small vessels, was atrributed both by the harbor officials and the press to the frequent and accurate warnings of Zikawei Observatory.

The *President Cleveland* rode out the storm safely in the river. During the 12 hours following noon, August 25, she was buffeted by winds of force 9 from almost the northeast; from 2 to 4 a. m. on August 26 the wind blew from the north with force 9; from 6 a. m. to 6 p. m. it continued backing from north-northwest, force 8, to west, force 2. The lowest barometer observed on board the *President Cleveland* at 3 a. m. August 26 was 726.90 mm. The press of Shanghai reported 723.90 mm. as the lowest barometric reading during the passage of this storm and compared it with the record barometric minimum 722.40 mm. on August 28, 1915, when the Chinhai typhoon destroyed several Shanghai vessels and exacted a toll of hundreds of lives. After passing Shanghai the typhoon inclined north-northeast, and, gaining speed, it moved decidedly east-northeast or northeast, crossing the Yellow Sea, northern Korea, and the whole Sea of Japan up to La Perousse Strait in 48

hours. The barometer at Nemuro fell to 741 mm. on August 28 at noon with the approach of the storm and rose to 759.5 mm. the next morning at 6 a. m. with the recession of the typhoon toward the Pacific. On the 24th and 25th this typhoon held complete and undivided sway over the whole Far East, the pressure and winds being controlled by it from southern Manchuria down to the Sulu Archipelago, over a distance of at least 2,000 miles. The steamers *President Madison*, *President Cleveland*, U. S. S. *Jason*, and U. S. S. *Parrot* were buffeted by the gales of the typhoon in the Eastern Sea.

The arrival of the *President Cleveland* with the honorable Secretary of War on board was delayed one day on account of the typhoon which the steamer encountered in the Eastern Sea. This typhoon and delay were mentioned in the proclamation of the Governor General of the Philippines transferring from August 31 to September 1 the special public holiday proclaimed on the occasion of the visit of the Secretary of War.

BUCKET OBSERVATIONS OF SEA-SURFACE TEMPERATURES

By Giles Slocum

STRAITS OF FLORIDA AND CARIBBEAN SEA

Table 1 shows the average temperatures for the Caribbean Sea and the Straits of Florida for August of each year from 1919 to 1930, inclusive, and Table 2 summarizes the temperature for August, 1930, in the same areas. The chart shows the number of observations taken in August, 1930, within each 1° square and mean temperature data for subdivisions of the areas considered.

For more detailed information regarding the methods of treating data, see the January, 1931, issue of the MONTHLY WEATHER REVIEW.

After remaining nearly stationary through much of July, the mean surface temperature of the Caribbean Sea rises throughout August, but at a rate somewhat less marked than during the spring and early summer weeks. In each of the 12 years treated (1919–1930) August has been warmer than July of the same year, and the August 11-year mean temperature (1920–1930) for each of the 5° subdivisions of the Caribbean is higher than that for the same area in July.

August is the warmest month in the Straits of Florida, and there is practically no variation of the mean temperature from one quarter month to the next, the 11-year average for each of the quarters of August being 83.9°.

The local distribution of temperatures remains much the same as in July. The straits are usually warmer than

any portion of the Caribbean, the western Caribbean warmer than the eastern, and the northern warmer than the southern except at the eastern extremity.

The differences from east to west are, however, less regularly progressive from lower temperature to higher than in July, and the average temperature is practically at a common level in all portions of the southern Caribbean except in the relatively cool central section.

The August, 1930, temperatures were above average in the Straits of Florida and the northern and extreme eastern Caribbean Sea and close to or below average in the southern Caribbean. The sea as a whole was, for the sixth consecutive month, warmer than the average.

TABLE 1.—*Mean sea-surface temperatures in the Caribbean Sea and the Straits of Florida for August, 1919–30*

Year	Caribbean Sea		Straits of Florida	
	Number of observations	Mean temperature	Number of observations	Mean temperature
1919 [1]	87	82.6	20	83.8
1920	157	81.4	47	82.5
1921	280	81.6	91	83.4
1922	192	81.5	70	84.0
1923	315	81.3	87	83.1
1924	318	82.5	121	84.9
1925	494	82.3	116	84.3
1926	491	82.9	142	84.1
1927	592	82.8	211	84.8
1928	566	82.6	166	84.0
1929	716	82.3	205	83.2
1930	589	82.5	153	84.3
Mean (1920–1930)		82.2		83.9

[1] Not used in computations because of insufficient data avilable.

TABLE 2.—*Mean sea-surface temperatures (°F.) and number of observations, August, 1930*

Quarter	Period	Caribbean Sea				Straits of Florida			
		Number of observations	Mean	Departure from 11-year mean (1920–1930)	Change from preceding month	Number of observations	Mean	Departure from 11-year mean (1920–1930)	Change from preceding month
			°F.	°F.	°F.		°F.	°F.	°F.
First	Aug. 1–7	136	82.1			37	84.2		
Second	Aug. 8–15	143	82.3			41	84.2		
Third	Aug. 16–23	153	82.8			38	84.6		
Fourth	Aug. 24–31	157	82.9			37	84.2		
Month		589	82.5	+0.3	+0.5	153	84.3	+0.4	+1.3

Distribution of Greenwich Mean Noon Bucket Observations of Sea-Surface Temperatures, August, 1931

(Plotted by Giles Slocum)

Heavy lines show boundaries of Straits of Florida and Caribbean Sea. Figures within the 1° squares show number of observations in each during the month.

On inset, heavy lines show boundaries of Straits of Florida and of 5° subdivisions of the Caribbean Sea. First number in each subdivision shows 11-year mean temperature for the month. Second number shows mean temperature for the month in 1930. Third number shows number of observations for the month.

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, August, 1931

[For description of tables and charts, see REVIEW, January, p. 50]

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section Average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	77.9	−1.7	Madison	102	1	Valley Head	47	22	4.60	+0.17	Seale	9.21	Mentone	1.36
Arizona	79.5	−0.4	2 stations	117	¹19	Williams	41	¹17	4.06	+1.81	Helvetia	11.27	Roll	0.26
Arkansas	76.7	−3.1	Booneville	103	8	Dutton	42	12	4.71	+0.90	Eureka Springs	14.67	Little Rock	1.29
California	74.5	+2.4	Greenland Ranch	123	24	Portola	28	8	0.24	+0.14	Kingston	3.12	97 stations	0.00
Colorado	66.6	+1.2	Cheyenne Wells	107	15	Pearl	17	29	1.37	−0.60	Cope	4.34	Florence	0.22
Florida	81.3	−0.1	Tallahassee	102	4	Garniers	55	24	6.27	−0.73	Marianna	12.57	Long Key	1.56
Georgia	79.0	−0.4	3 stations	104	¹2	Clayton	46	¹13	5.04	−0.13	Stillmore	12.41	Griffin	1.50
Idaho	68.7	+1.9	Orofino	109	17	Obsidian	25	27	0.20	−0.45	Grace	2.23	15 stations	0.00
Illinois	74.4	+0.3	White Hall	104	8	Mount Carroll	44	13	3.95	+0.54	Mascoutah	9.37	Aledo	0.81
Indiana	73.8	+0.6	Rome	104	1	2 stations	42	31	4.38	+1.04	Lafayette	7.89	Greencastle	1.86
Iowa	72.6	+0.9	2 stations	102	¹4	Decorah	37	30	3.30	−0.14	Lenox	7.18	Sioux Center	1.09
Kansas	76.0	−1.4	Ashland	109	26	Valley Falls	43	12	3.27	+0.17	Valley Falls	12.77	Toronto	0.27
Kentucky	74.9	−0.7	Bowling Green	102	1	Farmers	45	30	5.36	+1.63	Louisa	11.10	Beaver Dam	1.67
Louisiana	79.4	−2.4	2 stations	102	9	3 stations	52	¹13	4.91	−0.17	Burrwood	13.79	Arcadia	0.53
Maryland-Delaware	73.8	+0.6	3 stations	101	3	Sines, Md	40	30	7.70	+3.39	Cambridge, Md	14.49	Hancock, Md	3.04
Michigan	68.3	+1.7	Deer Park	104	5	Wolverine	24	31	1.86	−0.81	Bloomingdale	4.51	Ada	0.36
Minnesota	67.7	+0.9	2 stations	104	4	Mahnomen	27	29	2.83	−0.28	Rochester	6.43	Crookston	1.07
Mississippi	78.0	−2.5	Rosedale	100	4	Stoneville	51	14	3.74	−0.60	Biloxi	10.38	University	1.06
Missouri	74.9	−1.1	Chillicothe	106	8	2 stations	44	13	4.77	+1.02	Buffalo	11.00	La Grange	0.54
Montana	67.1	+2.5	Valentine	108	17	Upper Yaak River	18	17	0.48	−0.71	Culbertson (near)	2.19	3 stations	0.00
Nebraska	73.6	+0.7	Purdum	104	14	Gordon	33	29	2.27	−0.55	Geneva	6.75	Hull (near)	0.30
Nevada	73.3	+3.1	Las Vegas	115	24	Zorra Vista Ranch	28	8	0.86	+0.33	Searchlight	6.30	3 stations	0.00
New England	67.6	+0.8	Turner's Falls, Mass	99	6	Somerset, Vt	33	26	4.12	+0.24	West Rutland, Mass	10.78	Bethel, Vt	1.43
New Jersey	73.5	+1.5	3 stations	101	¹3	Charlotteburg	45	25	5.10	+0.36	Bridgeton	9.61	Phillipsburg	2.26
New Mexico	69.3	−0.9	2 stations	106	27	Therma (near)	26	25	3.07	+0.51	Cloudcroft	9.60	Albuquerque	0.23
New York	68.6	+1.3	West Point	105	7	Gabriels	33	26	3.05	−0.77	Bridgehampton	6.28	Ogdensburg	0.86
North Carolina	75.0	−0.8	2 stations	101	¹3	Mount Mitchell	38	23	7.52	+1.96	Red Springs	15.73	Cullowhee	2.57
North Dakota	67.0	+0.8	McLeod	105	4	Pembina	30	¹30	2.09	+0.05	Cando	4.95	Alpha	0.36
Ohio	72.7	+1.1	Vickery	103	7	2 stations	38	31	4.99	+1.65	Peebles	9.33	Wauseon	1.37
Oklahoma	79.2	−1.9	Buffalo	108	26	Hooker	43	29	2.79	−0.42	Claremore	9.01	Chattanooga	0.40
Oregon	66.4	+1.4	Umatilla	108	¹1	Seneca	19	¹26	0.02	−0.40	Crossett	0.48	52 stations	0.00
Pennsylvania	71.1	+1.1	Holtwood	104	8	2 stations	40	¹22	4.01	−0.16	Kregar	8.78	Franklin	1.30
South Carolina	78.2	−0.6	Cheraw	105	2	Caesars Head	50	¹13	4.84	−0.89	Marion	10.45	2 stations	1.84
South Dakota	72.5	+2.2	2 stations	108	¹4	Milbank	34	30	1.61	−0.79	Armour	5.63	Hardy Ranger Station	0.20
Tennessee	75.5	−0.9	do	101	¹1	Crossville	41	23	4.67	+0.66	Elkmont	14.26	Palmetto	1.09
Texas	81.1	−1.7	Fort Stockton	107	27	Spearman	48	29	2.04	−0.40	Eagle Pass	7.17	4 stations	0.00
Utah	71.6	+2.0	St. George	100	¹24	Coalville	28	27	0.75	−0.31	Yellowstone Ranger Station	2.20	Fort Duchesne	T.
Virginia	73.8	+0.1	Lincoln	102	8	Dale Enterprise	41	27	6.68	+2.30	Randolph	11.79	Winchester	2.81
Washington	65.8	0.0	2 stations	107	¹1	3 stations	31	¹7	0.16	−0.68	Palmer (near)	1.63	37 stations	0.00
West Virginia	71.6	+0.2	Charleston	102	2	2 stations	39	30	6.38	+2.22	Pickens	10.63	Kearneysville	1.62
Wisconsin	67.8	+0.7	7 stations	100	¹5	Coddington	26	30	2.74	−0.62	Mondovi	5.25	Appelton	1.10
Wyoming	65.0	+1.1	2 stations	103	¹4	Riverside	20	28	0.93	−0.20	Pathfinder	2.87	Eden	0.00
Alaska (July)	54.2	−1.8	do	84	¹2	Dillingham	27	9	2.40	−0.31	Mile Seven (Cordova)	11.47	St. Paul Island	0.32
Hawaii	75.6	+0.6	Waipahu	94	25	Kanalohuluhulu	49	29	8.12	+1.60	Hiloa - Manawaiopuna Divide	48.00	Reservoir No. 3	0.06
Porto Rico	79.8	+0.7	2 stations	98	29	Guineo Reservoir	55	24	6.64	−1.42	Rio Blanco	14.33	Ponce	2.72

¹ Other dates also.

Table 1.—Climatological data for Weather Bureau stations, August, 1931

District and station	Barom. above sea level (Ft.)	Therm. above ground (Ft.)	Anem. above ground (Ft.)	Station reduced to mean of 24 hrs (In.)	Sea level reduced to mean of 24 hrs (In.)	Press. dep. from normal (In.)	Mean max + mean min ÷2 (°F.)	Temp dep. from normal (°F.)	Max (°F.)	Date	Mean max (°F.)	Mean min (°F.)	Date	Greatest daily range (°F.)	Mean wet therm (°F.)	Mean dew point (°F.)	Mean rel. hum. (%)	Precip total (In.)	Precip dep. from normal (In.)	Days 0.01 or more	Wind total movement (Miles)	Prevail. direction	Max vel. mph	Max vel. dir.	Date	Clear days	Partly cloudy days	Cloudy days	Avg cloudiness tenths (0–10)	Snowfall (In.)	Snow on ground (In.)
New England							**68.8**	**+1.4**									**81**	**3.71**	**+0.1**										**5.8**		
Eastport	76	67	85	29.93	30.01	+0.05	62.2	+1.5	82	6	70	50	30	54	26	59	57	85	4.11	+1.1	16	4,293	s.	26	e.	12	4	9	18	7.4	0.0	0.0
Greenville, Me.	1,070	6		28.88	30.03		62.4		87	6	72	39	27	53	34	58		85	3.77		15	3,103	nw.	15		8	8	10	13		0.0	0.0
Portland, Me.	103	82	117	29.90	30.02	+.04	68.0	+1.6	98	6	75	54	2	60	34	61	57	74	3.41	+0.3	15	4,220	n.	22	nw.	6	16	5	10	5.0	0.0	0.0
Concord	289	70	79	29.72	30.02	+.04	67.6	+0.8	95	6	78	48	2	57	36				4.03	+0.5	12	2,415	n.	15	nw.	3	12	9	10	5.6	0.0	0.0
Burlington	403	11	48	29.59	30.02	+.05	66.6	−1.3	93	6	76	48	2	57	28			86	1.84	−1.5	12	4,152	s.	27	nw.	6	7	14	10	5.7	0.0	0.0
Northfield	876	12	60		30.05	+.07	62.6	−0.8	91	6	75	40	22	50	34			86	2.01	−1.5	12	3,230	s.	18	sw.	30	3	19	9	6.3	0.0	0.0
Boston	125	106	165	29.88	30.02	+.03	72.2	+2.3	97	6	80	58	25	65	25	64	61	74	4.45	+0.8	12	4,327	nw.	18	ne.	24	7	12	12	5.9	0.0	0.0
Nantucket	12	14	90	30.00	30.01	+.02	70.6	+2.8	86	7	77	60	2	64	18	66	65	87	3.49	−0.1	9	8,792	sw.	48	ne.	24	9	10	12	5.5	0.0	0.0
Block Island	26	11	46	29.98	30.01	+.02	71.0	+2.5	87	7	76	59	25	66	18	66	65	86	4.72	+1.0	11	8,858	sw.	36	nw.	17	9	10	12	5.9	0.0	0.0
Providence	160	215	251	29.85	30.02	+.03	72.2	+1.2	95	7	80	56	2	64	26	66	64	80	4.99	+1.5	13	5,916	nw.	34	nw.	3	11	7	13	5.3	0.0	0.0
Hartford	159	122		29.85	30.02	+.03	71.8	+2.9	95	7	80	53	25	63	29				4.45	+0.2	9		sw.				8	7	16	6.0	0.0	0.0
New Haven	106	74	153	29.90	30.02	+.03	72.8	+2.5	96	7	81	55	25	65	26	66	63	76	3.31	−1.0	10	4,966	n.	22	sw.	30	9	12	10	5.8	0.0	0.0
Middle Atlantic States							**74.1**	**+0.7**									**78**	**5.27**	**+1.0**										**6.0**		
Albany	97	107	115	29.92	30.02	+.04	71.0	+0.2	96	6	80	54	2	62	29	64	61	76	2.34	−1.4	10	3,847	s.	25	n.	17	10	13	8	5.0	0.0	0.0
Binghamton	871	10	84	29.12	30.04	+.05	69.9	+1.9	92	6	80	50	31	60	32				2.86	−0.7	9	2,728	ne.	18	w.	30	4	7	20	7.3	0.0	0.0
New York	314	414	454	29.68	30.03	.00	74.4	+1.3	93	7	81	61	24	68	20	66	63	73	3.26	−1.1	13	6,837	ne.	40	nw.	3	7	9	15	6.4	0.0	0.0
Bellefonte	1,050	5	30	28.94	30.03		68.4		92	7	80	45	31	57	35	63	61	81	2.80		9		sw.				6	8	17	7.0	0.0	0.0
Harrisburg	374	94	104	29.62	30.01	.00	73.8	+1.2	96	6	82	58	31	66	30	66	62	73	3.18	−0.9	13	3,330	w.	33	sw.	9	7	13	11	5.9	0.0	0.0
Philadelphia	114	123	367	29.90	30.04	+.02	76.3	+1.5	95	7	84	60	23	69	22	68	64	71	6.00	+1.4	16	7,450	sw.	36	n.	23	9	9	13	6.2	0.0	0.0
Reading	325	81	96	29.68	30.02		74.2	+1.3	96	6	83	58	24	66	23	66	63	72	4.72	+1.5	12	2,910	sw.	31	ne.	10	8	6	17	6.6	0.0	0.0
Scranton	805	111	119	29.19	30.04	+.04	71.2	+1.4	95	7	81	51	31	61	33	64	61	75	1.90	−1.8	12	3,348	sw.	30	sw.	12	7	14	10	5.8	0.0	0.0
Atlantic City	52	37	172	29.95	30.00	.00	74.5	+2.0	91	17	80	61	24	69	22	69	67	82	7.21	+2.7	11	10,194	s.	56	ne.	23	8	11	12	5.7	0.0	0.0
Cape May	17	13	49				74.0	+0.6	88	6	80	60	22	68	19	69	68	85	6.97	+2.7	11		s.				6	13	12		0.0	0.0
Sandy Hook	22	10	55	29.95	30.00		74.3		96	7	80	61	23	68	22	68	66	82	5.26	+0.3	13	7,746	sw.	38	ne.	11	5	10	16	6.5	0.0	0.0
Trenton	190	159	183	29.82	30.02		74.0	+1.0	96	7	82	58	23	66	26	67	64	76	6.39	+1.6	14	5,414	sw.	31	nw.	10	7	9	15	6.5	0.0	0.0
Baltimore	123	100	215	29.88	30.01	.00	77.0	+1.6	100	8	84	58	23	70	23	68	64	70	7.98	+3.6	19	5,703	sw.	30	sw.	3	8	11	12	5.9	0.0	0.0
Washington	112	62	85	29.90	30.01	.00	75.6	+0.6	98	8	84	56	22	67	27	68	65	76	5.92	+1.9	18	3,295	sw.	30	sw.	18	9	9	13	5.9	0.0	0.0
Cape Henry	18	8	54	29.99	30.01		77.2	+0.3	96	10	84	63	25	70	24	72	70	82	6.14	+1.3	15	6,560	sw.	38	ne.	22	10	13	8	5.3	0.0	0.0
Lynchburg	681	153	188	29.31	30.04	+.02	74.6	−1.0	96	4	84	55	30	65	28	67	65	78	5.16	+1.4	17	3,155	w.	26	nw.	2	10	16	5	5.0	0.0	0.0
Norfolk	91	170	205	29.93	30.03	+.03	77.8	+0.4	97	4	86	61	23	70	24	70	68	79	4.25	−1.0	14	6,528	sw.	68	nw.	19	11	10	10	5.7	0.0	0.0
Richmond	144	11	52	29.88	30.03	+.02	75.7	−0.8	95	3	84	58	24	67	26	70	68	86	11.42	+7.0	15	3,862	sw.	25	nw.	27	6	11	14	6.1	0.0	0.0
Wytheville	2,304	49	55	27.73	30.05	+.04	68.8	−1.7	87	2	79	48	30	58	31	63	62	84	3.83	−0.4	17	2,866	w.	21	w.	28	5	15	11	6.0	0.0	0.0
South Atlantic States							**78.2**	**+0.1**									**81**	**5.23**	**−0.4**										**5.8**		
Asheville	2,253	89	104	27.77	30.06	+.04	72.0	+1.5	92	1	83	50	24	61	34	64	63	85	4.01	−0.2	19	3,028	nw.	19	nw.	12	3	23	5	5.7	0.0	0.0
Charlotte	779	55	62	29.23	30.05	+.03	77.2	+0.1	96	1	87	58	23	68	26	69	67	78	8.13	+3.1	14	2,217	s.	18	nw.	20	7	12	12	5.9	0.0	0.0
Greensboro	886	6	56	29.12	30.06		73.8		92	4	83	51	24	64	29	68	67	89	10.29		16	3,864	sw.	30	w.	2	5	15	11	6.2	0.0	0.0
Hatteras	11	5	80	30.02	30.03	+.04	78.0	0.0	89	17	85	65	24	72	20	74	72	83	6.14	+0.4	13	6,508	sw.	32	nw.	29	12	13	6	4.6	0.0	0.0
Raleigh	376	103	146	29.65	30.04	+.02	76.2	−0.8	95	10	85	57	23	68	26	70	68	82	9.54	+1.1	16	3,998	sw.	39	nw.	2	6	16	9	6.4	0.0	0.0
Wilmington	78	81	91	29.98	30.06	+.06	78.5	+0.9	94	2	86	61	24	70	23	73	71	86	5.53	−0.8	16	3,545	sw.	19	w.	14	12	12	7	4.9	0.0	0.0
Charleston	48	11	92	30.01	30.06	+.05	80.0	−1.0	91	4	87	63	24	73	22	74	73	82	4.93	−1.6	13	5,738	sw.	28	se.	13	9	14	8	5.5	0.0	0.0
Columbia, S. C.	351	41	57	29.68	30.05	+.04	79.2	−0.2	96	2	89	58	24	70	26	71	68	77	2.20	−3.3	10	3,580	sw.	23	sw.	10	9	16	6	5.2	0.0	0.0
Due West	711	10	55	29.31	30.07		77.4		97	3	87	57	13	68	28				3.88		14	3,941	sw.	27	w.	6	4	16	11	6.0	0.0	0.0
Greenville, S. C.	1,039	139	146	28.97	30.05		76.8	+1.0	96	4	86	57	13	68		68	66	76	4.46	−1.0	12	4,023	ne.	38	sw.	12	6	19	6	5.4	0.0	0.0
Augusta	182	62	77	29.84	30.03	+.02	80.2	−0.2	101	3	90	59	24	70	28	72	69	77	4.54	−0.5	11	2,760	s.	21	nw.	5	5	17	9	5.3	0.0	0.0
Savannah	65	150	194	29.98	30.06	+.06	81.2	+0.4	97	5	90	62	24	72	25	73	71	81	3.23	−4.1	8	6,259	w.	37	w.	10	3	13	10	5.7	0.0	0.0
Jacksonville	43	209	245	30.02	30.07	+.06	80.8	−0.9	94	5	88	66	25	73	21	73	71	79	4.86	−1.0	13	6,559	s.	33	s.	4	7	14	10	6.0	0.0	0.0
Florida Peninsula							**83.0**	**+0.9**									**78**	**5.64**	**−0.7**										**6.1**		
Key West	22	10	64	30.01	30.03	+.05	83.8	+0.3	92	12	90	71	17	78	17	78	77	79	5.56	+1.0	14	4,940	se.	29	se.	14	9	13	9	5.9	0.0	0.0
Miami	25	124	168	30.03	30.06	+.03	83.0	+1.6	91	22	89	73	28	77	17	77	74	75	5.02	−1.2	10	5,370	e.	26	n.	24	2	16	13	6.5	0.0	0.0
Tampa	35	79	197	30.03	30.06	+.06	82.2	+0.7	94	5	90	69	12	74	22	75	73	81	6.35	−1.8	14	5,619	e.	38	ne.	27	0	20	11	6.6	0.0	0.0
Titusville	44	5			30.03	30.08	82.9		100	5	92	70	8	74	27				4.90		14		se.				6	16	9	5.9	0.0	0.0
East Gulf States							**78.8**	**−1.2**									**77**	**5.96**	**+0.7**										**5.6**		
Atlanta	1,173	190	198	28.85	30.06	+.05	77.0	0.0	94	3	86	57	23	68	23	67	63	69	2.44	−2.0	9	5,129	w.	23	nw.	22	10	14	7	5.0	0.0	0.0
Macon	370	78	87	29.67	30.06	+.05	79.0	−0.9	100	5	89	50	24	69	29	70	68	76	7.31	+3.0	12	3,175	sw.	25	nw.	27	11	7	13	5.6	0.0	0.0
Thomasville	273	49	103	29.77	30.06	+.06	79.2	−0.8	97	4	88	63	24	70	24	72	70	80	6.89	+1.1	14	3,567	sw.	22	nw.	2	13	16		7.1	0.0	0.0
Apalachicola	36	11	51	30.02	30.06		80.3		93	4	87	68	13	74	20	74	72	78	11.74	+4.2	14	4,112	w.	30	se.	14	8	8	15	6.4	0.0	0.0
Pensacola	56	149	185	30.00	30.07	+.09	78.9	−2.0	90	4	84	65	12	73	17	72	70	77	8.66	+0.6	10	6,715	se.	42	s.	10	3	22	6	5.8	0.0	0.0
Anniston	741	9	57				76.6	+0.2	96	3	88	53	23	66	34				2.81	−1.2	8	2,129	nw.	15	nw.	21	10	13	8		0.0	0.0
Birmingham	700	11	48	29.32	30.08	+.09	77.8	−1.4	95	5	88	58	12	67	29	69	66	78	4.69	+0.4	13	2,809	n.	25	se.	19	10	11	10	5.8	0.0	0.0
Mobile	57	125	161	30.01	30.07	+.09	79.6	−1.4	94	4	88	64	12	72	22	72	70	80	5.84	−1.1	9	4,846	n.	38	nw.	10	4	16	11	6.4	0.0	0.0
Montgomery	223	100	112	29.82	30.07	+.08	79.6	−1.2	96	1	89	63	24	70	27	70	67	75	4.07	−0.2	10	3,503	sw.	30	n.	10	11	11	9	5.5	0.0	0.0
Corinth	469	6					77.4		98	1	88	56	13	66	33				5.90		11		sw.				7	20	4		0.0	0.0
Meridian	375	87	95	29.68	30.06	+.07	77.8	−1.7	93	1	88	60	23	68	29	70	68	77	8.79	+4.2	10	2,925	sw.	18	nw.	10	11	13	7	4.9	0.0	0.0
Vicksburg	247	65	73	29.81	30.09	+.11	78.2	−2.6	93	31	87	61	12	69	24	70	68	77	2.99	−0.5	7	3,611	sw.	29	nw.	20	12	12	7	4.4	0.0	0.0
New Orleans	53	76	84	30.01	30.06	+.08	81.2	−1.0	94	8	88	69	26	74	21	73	71	76	3.54	−0.5	13	3,454	se.	17	ne.	15	6	19	6	5.2	0.0	0.0
West Gulf States							**80.7**	**−1.2**									**72**	**2.75**	**−0.3**										**4.2**		
Shreveport	249	204	220	29.78	30.04	+.07	80.3	−1.7	96	1	90	64	12	71	24	70	67	72	3.96	+1.3	6	5,618	s.	35	n.	28	13	15	3	4.2	0.0	0.0
Bentonville	1,303	11	44	28.69	30.04	+.07	73.9	−2.6	92	7	84	53	12	64	32				5.68		12	2,427	s.	17	sw.	9	24	6	1		0.0	0.0
Fort Smith	457	79	94	29.55	30.02	+.05	78.0	−2.3	98	9	87	59	29	68	27	70	66	74	8.71	+5.4	11	3,899	e.	28		10	13	8		5.3	0.0	0.0
Little Rock	357	136	153	29.68	30.05	+.07	77.8	−2.0	94	7	87	62	14	69	25	69	66	73	1.29	−2.8	10	4,754	sw.	24	sw.	17	9	7	15	6.0	0.0	0.0
Austin	605	136	148	29.38	30.01		83.1	−0.7	98	20	94	64	13	72	32	71	67	67	1.85	−0.2	4	4,868	s.	28	n.	21	15	16	0	3.6	0.0	0.0
Brownsville	57	83	100	29.94	30.00		82.0	−1.9	92	21	90	66	17	74	23	74	72	80	2.23	−0.3	7	6,155	se.	25	se.	25	15	13	3	3.7	0.0	0.0
Corpus Christi	20	11	78	30.00	30.02	+.09	82.4	−0.1	94	20	89	70	13	76	19	75	73	80	1.54	−0.7	8	6,900	se.	25	e.	23	13	13	5	4.4	0.0	0.0
Dallas	512	220	227	29.48	30.03		81.6		99	9	91	66	12	72	25				1.23	−1.5	4	7,727	s.	32	n.	28	17	14	0	3.1	0.0	0.0
Fort Worth	670	106	114	29.29	29.99	+.05	82.6	−0.4	99	9	93	62	12	72	29	69	62	67	3.38	+0.8	4	5,936	s.	27	sw.	9	9	20	2	4.4	0.0	0.0
Galveston	54	106	114	30.00	30.06	+.10	82.0	−0.8	91	10	87	70	16	78	16	75	72	75	4.23	0.0	14	6,014	s.	21	sw.	26	10	13	8	4.6	0.0	0.0
Houston	138	292	314	29.90	30.04		82.0	−1.2	97	10	90	64	15	74	27				3.62	−0.5	6	6,529	s.	31	se.	19	12	16	3	4.2	0.0	0.0
Palestine	510	64	72	29.52	30.04	+.07	80.2	−1.6	94	9	90	61	15	70	26	70	67	72	3.13	+1.0	8	4,269	s.	28	ne.	29	17	11	3	3.5	0.0	0.0
Port Arthur	34	58	66	30.00	30.04		81.8		97	10	89	64	15	74	27	74	71	77	3.06	−3.0	14	4,409	s.	28	n.	15	14	17	0	4.8	0.0	0.0
San Antonio	693	242	301	29.29	29.99	+.06	82.0	−1.5	96	10	92	64	15	72	25	72	68	72	0.30	−2.1	3	7,040	se.	31	s.	20	14	16	1	3.9	0.0	0.0
Taylor	571	38	51	29.46	30.06	+.11	82.8	+1.1	99	10	94	63	12	71	30				0.03	−2.4	1	5,353	s.	28	s.	20	19	10	2	2.7	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, August, 1931*—Continued

District and station	Elevation of instruments			Pressure			Temperature of the air									Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation			Wind		Maximum velocity			Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Mean minimum	Date	Mean minimum	Greatest daily range				Total	Departure from normal	Days with 0.01, or more	Total movement	Prevailing direction	Miles per hour	Direction	Date						
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee							74.5	-0.4										74	3.87	+0.4										5.8		
Chattanooga	762	190	215	29.24	30.04	+0.04	76.9	-0.6	95	3	86	56	13	67	30	68	64	70	2.67	-1.4	11	4,130	sw.	25	nw.	12	7	20	4	5.5	0.0	0.0
Knoxville	995	102	111	29.02	30.06	+.05	76.0	-0.2	96	3	86	56	13	66	31	68	65	76	3.40	-0.5	13	3,123	sw.	20	n.	1	4	18	9	5.8	0.0	0.0
Memphis	399	76	97	29.63	30.05	+.07	77.4	-2.0	92	7	85	60	12	70	20	70	66	74	2.25	-1.1	10	4,703	sw.	20	w.	19	11	10	10	5.0	0.0	0.0
Nashville	546	168	191	29.49	30.07	+.07	76.4	-1.4	96	1	86	57	13	67	31	68	65	74	3.94	+0.2	11	4,431	w.	26	nw.	20	9	12	10	5.7	0.0	0.0
Lexington	989	193	230	29.03	30.07	+.06	74.2	-0.3	92	1	82	58	12	66	23				2.40	-1.0	11	6,481	sw.	29	nw.	3	8	15	8	5.5	0.0	0.0
Louisville	525	188	234	29.48	30.06	+.06	75.9	-1.1	96	2	84	59	22	68	25	68	64	73	2.91	-0.5	13	5,440	s.	40	nw.	9	4	11	16	6.5	0.0	0.0
Evansville	431	76	116	29.58	30.04	+.05	76.4	-1.0	97	1	90	58	12	67	27	68	65	73	6.27	+2.9	11	4,669	sw.	37	s.	3	6	11	11	5.4	0.0	0.0
Indianapolis	822	194	230	29.16	30.03	+.03	74.6	+0.9	95	1	84	56	29	66	24	65	60	67	3.94	+1.4	10	5,714	sw.	28	nw.	29	11	14	6	5.0	0.0	0.0
Royal Center	736	11	55	29.26	30.04		71.6		93	1	83	51	12	61	31				3.69	+0.4	10	4,319	sw.	32	nw.	37	12	13	6	4.5	0.0	0.0
Terre Haute	575	96	129	29.42	30.03		75.0		96	1	85	56	12	65	28	66	62	71	2.58	+0.4	11	4,778	n.	31	sw.	2	9	14	8	5.2	0.0	0.0
Cincinnati	627	11	51	29.38	30.05	+.04	74.4	+0.8	96	1	84	56	23	65	26	66	64	77	4.24	+0.8	15	3,382	sw.	24	nw.	3	8	11	12	6.1	0.0	0.0
Columbus	822	216	230	29.17	30.03	+.02	72.8	-0.2	92	2	81	55	30	65	25	66	62	73	4.80	+1.5	14	4,802	s.	32	s.	28	6	14	11	6.2	0.0	0.0
Dayton	899	137	173	29.10	30.03		73.6	+0.2	94	1	82	55	23	65	26	66	62	72	2.27	-1.0	11	4,165	sw.	24	sw.	28	3	13	15	6.9	0.0	0.0
Elkins	1,947	50	67	28.08	30.08	+.06	68.2	-0.9	90	7	79	44	30	58	32	62	60	86	6.33	+2.5	15	2,243	w.	22	nw.	10	7	8	16	6.7	0.0	0.0
Parkersburg	637	77	82	29.42	30.07	+.06	73.8	-0.1	97	8	83	53	30	64	30	64	60	80	4.70	+1.2	15	2,788	se.	20	nw.	10	5	11	15	6.9	0.0	0.0
Pittsburgh	842	353	410	29.15	30.04	+.03	73.0	+0.1	94	8	82	55	31	64	25	65	61	72	3.50	+0.3	11	4,838	sw.	26	n.							
Lower Lake Region							71.3	+1.7										69	2.41	-0.6										5.5		
Buffalo	767	247	280	29.19	30.01	+.02	70.2	+1.6	86	2	77	55	31	64	25	63	59	72	2.58	-0.5	12	8,791	sw.	50	sw.	29	9	11	11	5.7	0.0	0.0
Canton	448	10	61	29.53	30.00		66.4	-1.4	90	6	77	46	31	56	33				1.51	-2.1	11	4,205	sw.	35	w.	8	5	8	15	8.1	0.0	0.0
Ithaca	836	74	100	29.13	30.02		70.6	+2.0	98	6	82	45	31	59	35	62	59	71	1.30	-2.1	9	4,151	nw.	18	s.	9	8	13	10	6.0	0.0	0.0
Oswego	335	71	85	29.65	30.02	+.03	69.6	+1.2	93	6	77	52	31	62	25	62	59	80	1.26	-1.3	8	4,883	n.	21	n.	19	8	11	12	5.9	0.0	0.0
Rochester	523	86	102	29.48	30.04	+.05	70.8	+1.6	95	6	79	51	31	63	26	63	58	67	1.84	-1.0	7	4,358	ne.	26	w.	29	8	11	12	5.8	0.0	0.0
Syracuse	596	65	79	29.40	30.03	+.04	71.0	+2.0	94	6	80	51	31	62	26				1.91	-1.0	6	3,320	s.	19	nw.	3	4	12	15	6.9	0.0	0.0
Erie	714	130	166	29.27	30.02	+.01	71.6	+2.0	92	6	79	53	31	64	23	66	64	78	1.78	-1.5	12	7,177	sw.	34	sw.	29	10	15	6	4.7	0.0	0.0
Cleveland	762	267	337	29.21	30.02	+.01	72.3	+2.3	94	2	79	56	31	66	22	64	59	65	2.75	0.0	14	7,087	sw.	35	n.	21	9	7	15	5.9	0.0	0.0
Sandusky	629	5	67	29.36	30.08	+.02	73.9	+2.1	98	2	82	48	31	65	29				6.39	+3.2	16	4,412	sw.	20	sw.	29	6	14	11	5.8	0.0	0.0
Toledo	628	208	243	29.36	30.08	+.03	73.2	+1.3	97	7	82	50	31	65	25	64	59	66	2.82	0.0	12	7,266	sw.	37	w.	29	12	11	8	5.0	0.0	0.0
Fort Wayne	856	100	119	29.12	30.03		73.0	+1.9	94	5	82	53	31	64	29	64	60	69	3.97	+0.9	16	4,326	sw.	28	se.	28	11	13	7	5.1	0.0	0.0
Detroit	730	218	258	29.26	30.04	+.03	73.2	+2.9	97	6	82	52	31	65	23	63	58	65	0.84	-1.9	8	6,002	sw.	33	sw.	29	7	17	7	5.1	0.0	0.0
Upper Lake Region							67.9	+1.7										70	2.05	-0.8										4.9		
Alpena	609	13	92	29.38	30.05	+.05	66.4	+2.3	90	17	75	40	31	57	30	60	56	72	1.75	-1.1	10	6,416	se.	25	se.	8	14	7	10	4.8	0.0	0.0
Escanaba	612	54	60	29.38	30.04	+.05	64.7	+0.4	93	5	73	41	30	56	26	59	55	73	1.25	-1.9	10	5,901	s.	26	n.	10	12	10	9	4.7	0.0	0.0
Grand Haven	632	54	89	29.35	30.02	+.03	69.1	+2.0	89	6	78	45	31	60	33	62	57	57	0.71	-2.2	8	6,477	sw.	32	nw.	29	15	9	10	4.6	0.0	0.0
Grand Rapids	707	70	244	29.27	30.08	+.03	72.4	+2.7	98	6	83	48	31	62	33	61	55	60	0.72	-1.9	6	6,521	w.	41	n.	17	9	10	12	5.3	0.0	0.0
Houghton	668	64	99	29.30	30.02	+.05	64.5	+0.8	92	4	74	42	31	56	22				1.98	-0.7	7	6,948	sw.	30	n.	11	9	16	6	5.6	T.	0.0
Lansing	878	6	88	29.10	30.02		69.8	+1.3	94	2	81	41	31	58	35	62	58	57	1.70	-1.1	7	4,593	sw.	27	sw.	28	9	11	11	5.0	0.0	0.0
Ludington	637	60	66	29.34	30.03		67.3	+2.0	88	17	75	43	31	60	27	61	57	71	2.06	-0.6	9	6,275	n.	33	n.	11	7	13	11	5.0	0.0	0.0
Marquette	734	77	111	29.23	30.02	+.04	65.4	+1.5	99	5	73	46	31	58	32	58	54	70	1.03	-1.6	8	6,183	w.	27	w.	29	7	17	7	5.2	0.0	0.0
Port Huron	636	70	120	29.34	30.04	+.05	70.8	+3.0	94	2	79	46	31	63	31	62	58	69	1.40	-1.3	12	6,314	n.	30	w.	29	7	11	13	5.0	0.0	0.0
Sault Sainte Marie	614	11	52	29.35	30.04	+.05	64.4	+2.3	94	8	74	40	31	55	24	57	53	73	1.80	-0.8	11	4,390	nw.	23	sw.	28	12	11	8	5.0	0.0	0.0
Chicago	673	7	131	29.27	30.04	+.04	73.2	+1.6	93	4	81	55	29	66	27	64	60	68	5.67	+2.5	9	6,050	ne.	27	w.	28	10	11	10	4.8	0.0	0.0
Green Bay	617	109	141	29.37	30.02	+.03	68.3	+0.5	97	5	78	43	30	60	31	60	55	55	2.34	-0.6	11	6,502	n.	28	w.	30	8	13	10	5.1	0.0	0.0
Milwaukee	681	125	221	29.30	30.04	+.04	71.8	+2.6	94	4	79	52	30	64	25	63	59	69	1.96	-0.7	8	7,988	w.	48	ne.	27	10	13	8	4.8	0.0	0.0
Duluth	1,133	5	47	28.80	30.00	+.03	63.9	+1.3	92	5	73	39	30	55	29	57	54	76	4.32	+1.1	9	7,131	ne.	32	w.	29	10	10	11	5.5	0.0	0.0
North Dakota							67.6	+1.5										65	2.11	-0.2										5.2		
Moorhead	940	50	58	28.98	29.98	+.02	67.6	+1.5	102	4	79	36	30	56	42	59	53	66	1.85	-1.0	6	5,373	s.	33	nw.	28	7	11	13	6.3	0.0	0.0
Bismarck	1,674	8	57	28.23	29.99	+.05	67.1	+0.2	99	4	79	45	30	56	36	59	53	67	1.58	-0.2	8	5,764	s.	31	n.	22	13	12	6	4.6	0.0	0.0
Devils Lake	1,478	11	44	28.43	29.98	+.04	66.2	+1.4	100	4	78	40	30	54	36	57	52	67	3.89	+1.4	8	5,972	nw.	30	nw.	28	9	11	11	5.8	0.0	0.0
Ellendale	1,457	10	56	28.45	30.00		68.0		101	4	81	46	30	56	45				2.15	-0.9	9	8,412	nw.	37	nw.	28	13	12	6	5.2	0.0	0.0
Grand Forks	833	12	67				67.8		102	4	79	36	30	56	42	58			2.01			8		se.	40	nw.	28	13	12	6		0.0	0.0
Williston	1,878	41	48	28.02	29.96	+.03	69.0	+2.9	96	21	81	41	28	57	39	58	51	60	1.10	-0.4	4	5,011	se.	39	nw.	7	15	10	6	3.9	0.0	0.0
Upper Mississippi Valley							73.4	+0.7										67	3.39	+0.1										5.0		
Minneapolis	918	102	206	29.02	29.98		70.6	+0.7	99	4	80	46	30	61	29				2.97	-0.2	8	6,696	s.	36	w.	28	6	11	14	6.5	0.0	0.0
St. Paul	837	114	149	29.12	30.01	+.04	70.5	+1.1	97	4	81	43	30	60	30				3.45	+0.4	11	5,195	sw.	26	nw.	28	9	9	13	5.5	0.0	0.0
La Crosse	714	11	48	29.25	30.01	+.03	71.0	+1.0	97	4	83	40	30	59	35	61	57	68	2.29	-1.4	9	2,407	s.	25	e.	27	15	5	11	5.2	0.0	0.0
Madison	974	70	78	29.00	30.02	+.03	71.0	+1.0	92	4	80	49	30	61	29	62	56	64	3.19	+2.0	8	4,708	sw.	31	e.	27	14	10	7	4.4	0.0	0.0
Wausau	1,247	4	62	28.73	30.04		66.8		97	5	79	39	30	56	40				2.67	-0.9	10	3,681	n.	24	w.	24	14	10	7	4.3	0.0	0.0
Charles City	1,015	10	51	28.97	30.03	+.00	72.0	+2.9	96	16	84	44	30	60	37	61	55	61	3.55	+0.1	8	3,662	se.	20	nw.	27	10	11	10	5.3	0.0	0.0
Davenport	606	71	79	29.39	30.03	+.05	74.6	+1.5	97	8	85	54	12	64	31	63	57	62	3.16	-0.3	8	4,785	ne.	48	sw.	29	9	11	11	5.0	0.0	0.0
Des Moines	861	5	99	29.13	30.02	+.05	75.0	+0.3	92	6	84	50	29	62	34	64	59	67	3.66	+0.1	13	4,873	s.	29	w.	27	9	7	15	5.9	0.0	0.0
Dubuque	700	81	96	29.32	30.05	+.07	73.1	+1.4	94	4	84	51	12	62	31	62	56	65	2.02	-1.2	5	3,184	sw.	25	nw.	27	8	12	11	6.3	0.0	0.0
Keokuk	614	64	78	29.36	30.05	+.07	74.6	-0.4	100	8	85	54	12	64	30	65	60	65	2.40	-0.8	9	4,403	s.	26	n.	11	7	8	16	6.1	0.0	0.0
Cairo	358	87	93	29.66	30.05	+.06	76.2	-1.6	92	1	84	56	13	68	23	69	66	71	7.14	+4.1	9	2,564	ne.	16	nw.	27	17	9	5	3.6	0.0	0.0
Peoria	609	11	45	29.39	30.05	+.06	74.6	+1.5	98	8	85	55	29	65	28	66	62	70	3.58	+0.4	6	5,983	n.	27	w.	27	8	14	9	5.4	0.0	0.0
Springfield, Ill.	636	5	191	29.36	30.02	+.05	75.6	+1.1	100	8	86	55	29	65	28	66	62	70	2.71	-0.6	7	3,916	sw.	24	w.	28	8	14	9	4.5	0.0	0.0
Hannibal	534	74	109	29.47	30.04	+.06	75.0	0.0	100	8	85	53	13	65	30				3.46	+0.5	11	5,608	s.	33	nw.	2	16	9	6	3.9	0.0	0.0
St. Louis	568	265	303	29.43	30.03	+.04	77.0	-1.0	100	8	86	58	12	68	27	67	63	68	4.22	+5.3										4.5		
Missouri Valley							74.7	+0.8										63														
Columbia, Mo.	784	6	84	29.21	30.03	+.06	75.0	-0.6	98	7	86	53	13	65	31				8.86	+1.0	10	3,520	sw.	31	nw.	31	13	10	8	4.7	0.0	0.0
Kansas City	963	161	181	29.02	30.03	+.06	76.0	-0.6	97	7	85	56	11	67	27	66	62	66	4.33	-0.6	9	4,780	se.	27	n.	9	13	12	6	4.4	0.0	0.0
St. Joseph	967	11	49	29.00	30.01		75.2		95	1	86	50	12	64	33	66	62	71	5.27	+1.8	11	5,121	s.	30	nw.	9	16	10	5	3.6	0.0	0.0
Springfield, Mo.	1,324	98	104	28.66	30.05	+.08	73.0	-2.7	91	1	81	55	13	65	24	66	63	75	10.68	+6.6	11	3,095	s.	19	n.	9	11	13	7	5.2	0.0	0.0
Iola	984	11	50	28.99	30.01	+.05	76.6	-0.5	101	8	88	50	12	65	34				6.48	+2.4	10	4,757	se.	35	nw.	31	11	13	7	4.9	0.0	0.0
Topeka	987	92	107				74.8	-1.4	96	1	85	54	12	65	36				3.79	+0.2	8	5,295	s.	29	s.	1	10	13	8	5.0	0.0	0.0
Lincoln	1,189	11	81	28.76	29.99	+.04	75.1	+0.7	93	31	87	51	29	64	33	65	60	66	3.79	+0.2	9	3,931	s.	32	nw.	31	11	14	6	4.9	0.0	0.0
Omaha	1,105	115	122	28.86	30.01	+.05	75.4	+1.0	92	23	86	53	11	65	33	64	53	57	4.43	+1.4	7	5,955	n.	32	sw.	13	11	13	7	4.9	0.0	0.0
Valentine	2,508	47	54	27.34	30.01	+.07	72.8	+1.1	98	13	86	43	11	64	46	60	53	57	2.58	+0.9	7	6,957	s.	34	nw.	28	14	7	10	4.9	0.0	0.0
Sioux City	1,135	94	164	28.80	29.98	+.03	74.8	+2.8	95	3	86	53	29	64	35	63	57	60	3.90	+0.8	7	6,957	s.	34	nw.	28	17	7	7	4.0	0.0	0.0
Huron	1,306	59	74	28.62	29.99	+.04	74.6	+3.4	102	4	86	45	30	66	45	60	52	54	0.44	-1.9	4	6,506	s.	28	w.	27	9	14	8	4.9	0.0	0.0
Pierre	1,672	70	75	28.32	29.96	+.02	75.2	+2.4	104	4	88	46	11	63	46	61	52	51	0.44	-2.6	6	4,504	s.	36	nw.	25	e.						
Yankton	1,233	49	57	28.70	29.99	+.04	75.4	+3.4	99	3	88	48	11	63	42												18	13	10	8	4.6	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau Stations, August, 1931*—Continued

District and station	Elevation of instruments			Pressure			Temperature of the air									Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation			Wind		Maximum velocity			Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max.+ mean min.+2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range				Total	Departure from normal	Days with 0.01, or more	Total movement	Prevailing direction	Miles per hour	Direction	Date						
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Northern Slope							68.9	+2.6										50	0.62	-0.6										4.0		
Billings	3,140	5					70.2		101	11	90	40	28	51	57				0.59		5		nw.	22	nw.	26	14	12	5		0.0	0.0
Havre	2,505	11	44	27.38	29.96	+.07	68.7	+3.3	95	20	84	45	9	54	46	54	44	50	0.22	-1.0	2	4,711	nw.	22	nw.	26	17	11	3	3.4	0.0	0.0
Helena	4,124	80	113	25.86	29.96	+.02	69.7	+4.7	95	11	84	44	28	55	43	55	43	47	0.06	-0.7	3	5,258	sw.	37	sw.	21	12	13	6	4.5	0.0	0.0
Kalispell	2,973	48	86	26.93	29.95	+.02	67.0	+4.2	93	17	84	40	8	50	42	51	36	40	0.01	-0.9	1	3,960	nw.	23	w.	26	14	12	5	3.7	0.0	0.0
Miles City	2,371	48	55	27.49	29.90	+.06	73.5	+2.0	95	19	87	47	28	60	38	58	48	48	0.17	-0.9	3	4,178	s.	31	nw.	26	19	7	5	3.3	0.0	0.0
Rapid City	3,259	50	58	26.67	30.01	+.08	71.1	-1.6	101	12	84	45	10	58	43	57	47	49	1.00	-0.7	11	4,842	n.	32	nw.	24	13	14	4	4.1	0.0	0.0
Cheyenne	6,088	84	101	24.16	30.00	+.08	66.6	+1.0	90	13	80	42	28	54	38	52	44	54	2.70	+1.2	11	5,443	w.	44	w.	26	10	14	7	4.8	0.0	0.0
Lander	5,372	60	68	24.77	30.00	+.08	67.8	+2.3	92	11	83	40	28	52	43	53	44	50	0.50	+0.1	5	2,931	sw.	35	nw.	23	16	12	3	3.5	0.0	0.0
Sheridan	3,790	10	47	26.16	30.00		69.2		97	11	86	39	29	52	50	55	47	56	0.14	-0.8	4	2,295	nw.	24	nw.	26	11	18	2	4.2	0.0	0.0
Yellowstone Park	6,241	11	48	24.03	30.03	+.10	62.6	+1.7	87	11	78	33	28	47	45	48	36	46	0.75	-0.3	7	4,336	sw.	30	sw.	7	10	16	5	4.7	0.0	0.0
North Platte	2,821	11	51	27.12	29.99	+.05	73.8	+3.0	98	14	87	44	29	60	47	61	54	59	0.58	-1.8	9	4,260	s.	21	ne.	31	16	7	8	4.1	0.0	0.0
Middle Slope							75.9	-0.1										57	2.33	-0.2										4.1		
Denver	5,292	106	113	24.85	30.00	+.08	72.2	+1.5	95	12	84	50	28	60	34	56	46	48	2.36	+0.9	7	4,262	s.	23	w.	26	14	11	6	4.0	0.0	0.0
Pueblo	4,685	80	86	25.39	29.97	+.06	74.0	-1.3	98	14	89	51	24	60	38	57	47	47	0.83	-1.0	8	3,875	e.	26	nw.	22	17	12	2	3.9	0.0	0.0
Concordia	1,392	50	58	28.58	30.02	+.07	75.4	-1.1	100	30	86	53	29	64	38	65	61	69	5.18	+2.3	12	3,920	s.	20	sw.	30	16	10	5	3.8	0.0	0.0
Dodge City	2,509	88	100	27.46	30.01	+.08	76.2	-1.5	104	26	88	56	11	64	39	63	57	59	1.52	-1.2	9	7,540	s.	32	e.	5	21	6	4	3.0	0.0	0.0
Wichita	1,358	139	158	28.59	29.99	+.04	77.2	-1.1	99	8	87	56	11	66	29	65	59	60	1.91	-1.2	9	7,014	s.	37	s.	31	12	12	7	4.7	0.0	0.0
Oklahoma City	1,214	10	47	28.74	29.90	+.05	80.2	+0.5	100	26	92	57	29	69	33	67	61	61	2.17	-0.7	8	5,452	s.	24	se.	31	10	13	8	5.1	0.0	0.0
Southern Slope							79.0	-0.6										60	1.94	-0.4										4.2		
Abilene	1,738	10	52	28.22	29.98	+.06	82.4	+0.4	99	6	94	60	11	71	32	66	58	53	0.31	-1.9	3	6,318	s.	30	sw.	31	11	13	7	4.5	0.0	0.0
Amarillo	3,676	10	49	26.35	30.00	+.08	76.1	+0.4	97	20	88	57	29	65	32	63	56	58	2.19	-0.9	8	5,200	s.	19	s.	30	13	12	6	4.3	0.0	0.0
Del Rio	944	64	71	28.97	29.94	+.04	82.0	-2.2	98	21	92	66	12	71	27	71	66	66	2.56	+0.8	4	5,894	se.	35	e.	22	13	17	1	4.0	0.0	0.0
Roswell	3,566	75	85	26.43	29.97	+.09	75.5	-1.1	98	27	88	55	11	63	38	63	57	61	2.71	+0.6	11	4,113	s.	27	ne.	20	15	11	5	4.0	0.0	0.0
Southern Plateau							78.2	+0.8										56	1.94	+0.8										3.8		
El Paso	3,778	152	175	26.22	29.91	+.07	79.5	+0.3	100	27	91	60	23	68	34	63	55	49	2.14	+0.4	8	5,634	e.	41	ne.	23	13	15	3	3.9	0.0	0.0
Albuquerque	4,972	51	66	25.14	29.90		74.4		95	26	88	54	13	61	37	59	51	52	0.23		6	3,606	sw.	24	se.	16	12	16	3	4.2	0.0	0.0
Santa Fe	7,013	38	53	23.41	29.95	+.06	67.0	-0.4	87	26	79	48	24	55	33	53	46	58	2.10	-0.2	13	3,156	e.	22	s.	29	13	12	6	4.5	0.0	0.0
Flagstaff	6,907	10	59	23.50	29.94	+.10	64.2	+1.4	86	24	78	46	24	50	40	54		72	3.56		15	4,042	nw.	26	se.	25	3	18	10		0.0	0.0
Phoenix	1,108	10	107	28.72	29.85	+.04	89.3	+0.8	110	19	101	72	31	78	33	71	62	48	1.70	+0.8	7	3,338	e.	42	s.	27	16	10	5	3.5	0.0	0.0
Yuma	141	9	54	29.68	29.82	+.06	90.1	-0.3	113	19	103	68	21	78	31	78	33	54	2.22	+1.7	8	2,941	s.	28	w.	31	19	8	4	2.0	0.0	0.0
Independence	3,957	6	27	26.00	29.94	+.13	79.1	+3.0	102	25	93	59	31	65	35	59			1.51	+1.4	5		s.				17	7	7		0.0	0.0
Middle Plateau							74.6	+3.5										36	0.61	-0.1										3.0		
Reno	4,532	74	81	25.51	29.90	+.06	74.2	+7.2	98	23	91	50	27	58	45	53	37	32	0.95	+0.7	1	4,135	w.	27	sw.	25	20	7	4	3.0	0.0	0.0
Tonopah	6,090	12	20				73.9		91	3	84	54	30	64	26	55	42	38	1.74		6		se.										
Winnemucca	4,344	18	56	25.65	29.95	+.07	73.2	+3.9	99	3	92	44	22	54	54	51	32	47	0.16	-0.0	2	4,433	sw.	26	se.	16	22	7	2	2.3	0.0	0.0
Modena	5,473	10	43	24.70	29.91	+.05	71.8	-2.6	97	25	87	48	28	56	41	55	44	46	0.46	-0.8	8	6,235	sw.	45	sw.	29	16	11	4	4.1	0.0	0.0
Salt Lake City	4,360	163	203	25.67	29.94	+.03	76.6	+2.1	98	23	89	55	27	65	33	57	43	34	1.07	+0.2	5	4,595	s.	42	w.	21	21	8	2	2.7	0.0	0.0
Grand Junction	4,602	60	68	25.43	29.94	+.04	77.2	+1.8	98	25	91	54	28	63	35	56	42	36	0.40	-0.8	3	3,620	se.	31	sw.	6	17	12	2	3.1	0.0	0.0
Northern Plateau							73.1	+3.2										34	0.09	-0.4										2.4		
Baker	3,471	48	53	26.48	30.00	+.05	68.6	+4.0	97	10	87	42	6	50	46	50	33	32	0.04	-0.4	3	3,529	se.	17	sw.	10	22	8	1	2.1	0.0	0.0
Boise	2,739	79	87	27.15	29.94	+.01	75.1	+3.3	100	10	91	49	27	59	41	55	38	30	0.05	-0.1	2	2,713	nw.	17	se.	14	21	7	3	2.6	0.0	0.0
Lewiston	757	40	48	29.16	29.96	+.01	75.0	+2.2	102	23	92	51	22	58	48			36	0.02	-0.6	1	2,276	w.	22	nw.	3	20	8	3	2.5	0.0	0.0
Pocatello	4,477	60	68	25.54	29.96	+.04	72.4	+2.8	97	11	86	45	27	53	44	54	39	38	0.54	-0.2	3	4,572	se.	41	sw.	18	13	10	8	4.5	0.0	0.0
Pasco	416	5	33				74.6		104	2	93	47	14	56	53			36	T.		0	4,981	sw.				26	4	1		0.0	0.0
Spokane	1,929	101	110	27.96	29.96	+.01	71.2	+3.1	97	17	87	47	8	56	44	52	35	33	0.01	-0.6	1	3,222	s.	19	s.	21	23	5	3	2.3	0.0	0.0
Walla Walla	991	57	65	28.90	29.96	.00	75.4	+2.7	99	1	89	54	8	62	41	56	38	30	T.		0	2,726	w.	15	w.	5	26	4	1	1.5	0.0	0.0
Yakima	1,076	58	67	28.84	29.98		73.8	+4.3	90	2	80	50	6	59	39	56	41	36	T.		0	4,363	nw.	21	sw.	3	29	2	0	1.2	0.0	0.0
North Pacific Coast Region							62.8	+0.6										68	0.18	-0.6										3.6		
North Head	211	11	56	29.90	30.12	+.09	56.7	-1.0	77	28	61	47	8	52	21	55	54	91	0.22	-0.8	5	9,066	n.	34	n.	1	4	17	10	6.1	0.0	0.0
Port Angeles	29	8	53		30.11		58.8		85	9	67	45	4	50	33				0.05	-0.7	1	3,921	sw.	20	w.	29	15	11	5		0.0	0.0
Seattle	125	215	250	29.94	30.07	+.07	64.2	+1.1	91	9	74	51	4	55	33	57	51	67	0.11	-0.6	4	4,203	ne.	21	s.	9	17	11	3	3.5	0.0	0.0
Tacoma	194	172	201	29.88	30.08	+.04	63.9	+1.3	94	9	74	49	16	54	38				0.21	-0.5	3	4,827	n.	45	sw.	9	13	16	2	3.8	0.0	0.0
Tatoosh Island	86	9	53	30.01	30.10	+.10	54.9	-0.4	67	9	59	47	20	51	15	54	53	94	0.83	-1.2	7	6,832	s.	40	s.	9	4	11	16	6.7	0.0	0.0
Medford	1,329	29	58	28.57	29.95		72.1		103	1	92	44	6	52	50	55	40	40	T.	-0.2	0	3,933	nw.	24	nw.	17	27	2	2	1.2	0.0	0.0
Portland, Oreg	153	68	106	29.89	30.05	+.04	69.2	+2.5	96	28	81	52	4	57	35	59	52	60	0.04	-0.6	1	3,844	nw.	16	nw.	27	20	9	2	3.0	0.0	0.0
Roseburg	510	75	99	29.49	30.03	+.03	68.0	0.0	98	28	84	46	6	52	44	56	46	55	T.	-0.3	0	2,859	n.	18	n.	20	25	6	0	1.2	0.0	0.0
Middle Pacific Coast Region							68.1	+1.3										53	T.	0.0										3.1		
Eureka	62	73	89	29.99	30.06	+.06	55.3	-0.7	64	20	59	48	5	51	14	53	51	87	0.01	-0.2	1	3,468	nw.	17	nw.	11	6	15	10	5.7	0.0	0.0
Red Bluff	330	5	58	29.52	29.86	.00	82.4	+2.7	107	24	99	60	9	65	42	60	40	27	T.	0.0	0	3,219	s.	16	n.	26	26	3	2	1.5	0.0	0.0
Redding	722	20	34				83.6		106	24	98	62	7	69	34			22	0.00		0	4,876	nw.				23	8	0		0.0	0.0
Sacramento	69	106	117	29.80	29.87	+.04	74.6	+1.7	108	24	93	50	9	57	44	59	49	50	T.	0.0	0	5,449	s.	17	sw.	13	27	4	0	1.1	0.0	0.0
San Francisco	155	208	243	29.78	29.95	+.03	60.4	+1.3	89	23	68	51	9	53	35	54	51	79	0.00	0.0	0	4,064	sw.	22	w.	17	12	16	3	4.5	0.0	0.0
San Jose	141	12	110	29.80	29.95		68.0	+1.3	99	24	82	47	19	54	45				T.	0.0	0	3,621	nw.	20	se.	6	21	8	2	2.9	0.0	0.0
South Pacific Coast Region							76.1	+4.6										60	0.03	0.0										3.3		
Fresno	327	89	98	29.52	29.86	+.04	84.4	+3.7	110	24	100	63	19	69	39	61	42	27	T.	0.0	0	4,778	nw.	28	nw.	4	23	5	3	2.2	0.0	0.0
Los Angeles	338	159	191	29.57	29.92	+.04	76.1	+5.0	97	25	85	64	6	67	25	66	63	71	0.02	0.0	2	2,892	sw.	14	w.	24	20	8	3	3.1	0.0	0.0
San Diego	87	62	70	29.83	29.92	+.03	73.8	+5.1	88	28	78	65	21	69	16	68	65	82	0.08	0.0	4	3,961	w.	16	w.	19	16	9	6	4.5	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.92	30.01		81.4	+0.9	91	3	86	74	14	77	15				5.54	-0.4	23	9,162	e.	32	e.	8	8	17	6	5.3	0.0	0.0
Panama Canal																																
Balboa Heights	118	6	97		[1] 29.82	-.01	81.2	0.0	92	21	87	72	8	75	17		[1] 86	4.28	-3.6	16	4,363	nw.	20	nw.	10	0	11	20	7.9	0.0	0.0
Cristobal	36	6	97		[1] 29.83	-.01	81.8	+1.5	90	22	87	74	6	77	16	77	76	[1] 85	17.52	+2.1	25	5,090	w.	28	w.	8	0	1	30	9.4	0.0	0.0
Alaska																																
Fairbanks	455	11	44	[1] 29.41	[1] 29.92		53.0		70	16	64	28	20	42	37	49	45	76	2.80		12	2,632	sw.	17	nw.	18	8	6	17	6.6	0.0	0.0
Juneau	80	11	80	[1] 29.96	[1] 30.05		55.6		74	10	60	46	4	51	25	53	51	88	11.31		23	3,541	s.	26	s.	10	3	1	27	8.7	0.0	0.0
Hawaiian Islands																																
Honolulu	38	86	100	[1] 29.97	[1] 30.01		78.6	+0.2	84	14	83	72	12	74	11	72	69	74	1.83	+0.6	14	6,767	e.	24	ne.	6	9	15	7	5.5	0.0	0.0

[1] Observations taken bihourly.   [1] Pressure not reduced to mean of 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, August, 1931*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max.+ mean min.÷2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	Inches	Inches	Inches	°F.	°F.	°F.	°F.	°F.	°F.	Inches	Inches	Inches
Cape Race, N. F.	99				57.8		65.0	50.6	74	42	2.75		0.0
Sydney, C. B. I.	48												
Yarmouth, N. S.	65												
Charlottetown, P. E. I.	38												
Chatham, N. B.	28												
Father Point, Que.	20												
Quebec, Que.	296	29.70	30.02	+0.09	64.4	+1.3	72.9	55.8	84	46	2.31	-1.52	0.0
Doucet, Que.	1,236												
Montreal, Que.	187	29.79	29.99	+.04	69.0	+2.6	77.4	60.7	90	53	1.75	-1.82	0.0
Ottawa, Ont.	236	29.75	30.01	+.05	70.2	+5.4	82.5	57.9	99	50	0.57	-2.46	0.0
Kingston, Ont.	285												
Toronto, Ont.	379	29.62	30.01	+.02	69.4	+3.4	78.3	60.5	92	46	2.10	-0.66	0.0
Cochrane, Ont.	930				61.2		72.5	50.0	97	37	1.53		0.0
White River, Ont.	1,244	28.69	29.99	+.03	58.0	+1.6	73.2	42.8	90	27	2.86	-0.44	0.0
London, Ont.	808				69.0		80.2	57.9	96	40	2.60		0.0
Southampton, Ont.	656												
Parry Sound, Ont.	688	29.34	30.02	+.04	67.0	+3.5	76.5	57.5	88	46	1.71	-1.01	0.0
Port Arthur, Ont.	644	29.30	30.01	+.05	63.7	+4.2	74.1	53.3	94	38	1.54	-1.21	0.0
Winnipeg, Man.	760	29.13	29.94	.00	66.8	+3.4	78.2	55.5	100	36	2.02	-0.65	0.0
Minnedosa, Man.	1,690	28.18	29.96	+.02	63.4	+4.0	76.5	50.2	98	36	2.96	+0.86	0.0
Le Pas, Man.	860				62.2		72.7	51.7	83	39	2.88		0.0
Qu'Appelle, Sask.	2,115	27.78	29.94	+.01	63.7	+2.2	76.2	51.2	92	35	2.45	+0.81	0.0
Moose Jaw, Sask.	1,759				65.7		79.1	52.3	93	38	3.11		0.0
Swift Current, Sask.	2,392	27.44	29.91	-.02	65.2	+1.2	79.6	50.7	98	36	2.16	+0.25	0.0
Medicine Hat, Alb.	2,365												
Calgary, Alb.	3,428												
Banff, Alb.	4,521												
Prince Albert, Sask.	1,450	28.42	29.97	+.05	63.5	+4.6	75.2	51.8	92	40	1.35	-0 80	0.0
Battleford, Sask.	1,592	28.23	29.95	+.04	63.1	+0.5	76.8	49.4	99	38	0.82	-1.54	0.0
Edmonton, Alb.	2,150												
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.82	30.07	+.06	60.0	+1.3	68.0	52.1	84	50	0.20	-0.40	0.0
Barkerville, B. C.	4,180												
Estevan Point, B. C.	20												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151												

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Stations	Altitude	Station reduced	Sea level reduced	Departure	Mean max.+min.	Departure	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure	Total snowfall
Cape Race, N. F.	99	29.90	29.95	+.02	55.8		60.0	51.6	74	45	2.44		0.0
Sydney, C. B. I.	48	29.84	29.94	-.02	68.2	+5.9	77.3	59.2	87	50	2.10	-1.55	0.0
Halifax, N. S.	88	29.84	29.94	-.02	67.0	+3.6	75.1	59.0	85	50	2.81	-1.24	0.0
Yarmouth, N. S.	65	29.82	29.89	-.06	64.3	+4.8	71.7	56.9	79	46	1.31	-2.16	0.0
Charlottetown, P. E. I.	38	29.80	29.84	-.06	69.0	+4.9	76.4	61.6	87	52	2.04	-1.45	0.0
Chatham, N. B.	28	29.76	29.79	-.09	69.2	+4.2	78.7	59.8	91	48	4.18	-0.01	0.0
Father Point, Que.	20	29.78	29.80	-.05	59.2	+1.6	67.8	50.6	82	45	4.68	+1.64	0.0
Quebec, Que.	296	29.55	29.86	-.05	68.6	+3.1	76.9	60.3	86	51	3.70	-0.56	0.0
Doucet, Que.	1,236				63.8		76.7	51.0	95	33	7.17		0.0
Montreal, Que.	187	29.64	29.84	-.09	73.7	+5.2	82.8	64.6	97	56	4.23	-0.06	0.0
Kingston, Ont.	285	29.58	29.88	-.09	71.6	+3.4	78.2	65.0	89	56	3.63	+0.74	0.0
Toronto, Ont.	379	29.50	29.89	-.08	73.6	+5.6	82.7	64.5	98	54	3.10	+0.18	0.0
Cochrane, Ont.	930				67.0		78.0	56.0	90	47	3.61		0.0
White River, Ont.	1,244	28.55	29.84	-.10	63.6	+4.1	77.6	49.7	99	33	3.43	+0.63	0.0
London, Ont.	808				73.2		84.3	62.2	99	50	5.64		0.0
Southampton, Ont.	656	29.20	29.91	-.06	70.0	+5.3	79.0	61.0	92	50	2.69	+0.71	0.0
Parry Sound, Ont.	688	29.22	29.90	-.06	70.8	+4.8	79.6	62.0	93	52	3.39	+0.77	0.0
Port Arthur, Ont.	644	29.17	29.86	-.08	66.5	+4.5	77.5	55.5	94	46	2.63	-0.85	0.0
Winnipeg, Man.	760	29.04	29.85	-.08	68.4	+2.4	79.4	57.4	98	48	3.08	0.00	0.0
Minnedosa, Man.	1,690	28.09	29.87	-.06	65.0	+2.8	76.9	53.2	98	43	2.99	+0.39	0.0
Le Pas, Man.	860				64.1		74.6	53.5	91	42	2.84		0.0
Qu'Appelle, Sask.	2,115	27.65	29.86	-.06	65.8	+2.3	78.6	53.0	101	40	1.80	-0.68	0.0
Moose Jaw, Sask.	1,759				69.3		83.3	55.2	102	44	0.73		0.0
Swift Current, Sask.	2,392	27.38	29.84	-.07	67.6	+1.1	82.6	52.7	103	40	1.18	-1.26	0.0
Prince Albert, Sask.	1,450	28.34	29.89	-.02	65.7	+3.8	77.2	54.3	93	45	1.25	-0.80	0.0
Battleford, Sask.	1,592	28.16	29.87	-.03	65.0	+0.3	78.0	52.0	91	39	1.20	-1.14	0.0
Edmonton, Alb.	2,150	27.63	29.87	-.03	61.5	+0.9	73.5	49.6	88	39	3.06	+0.03	0.0
Victoria, B. C.	230	29.76	30.01	-.04	61.5	+1.5	69.7	53.3	86	49	0.33	-0.07	0.0

TABLE 2.—Data furnished by the Canadian Meteorological Service, August, 1931.

LATE REPORTS—JULY, 1931

Chart I. Departure (°F.) of the Mean Temperature from the Normal, August, 1931

Chart I. Departure (°F.) of the Mean Temperature from the Normal, August, 1931

Shaded portions show excess (+).
Unshaded portions show deficiency (—).
Lines show amount of excess or deficiency.
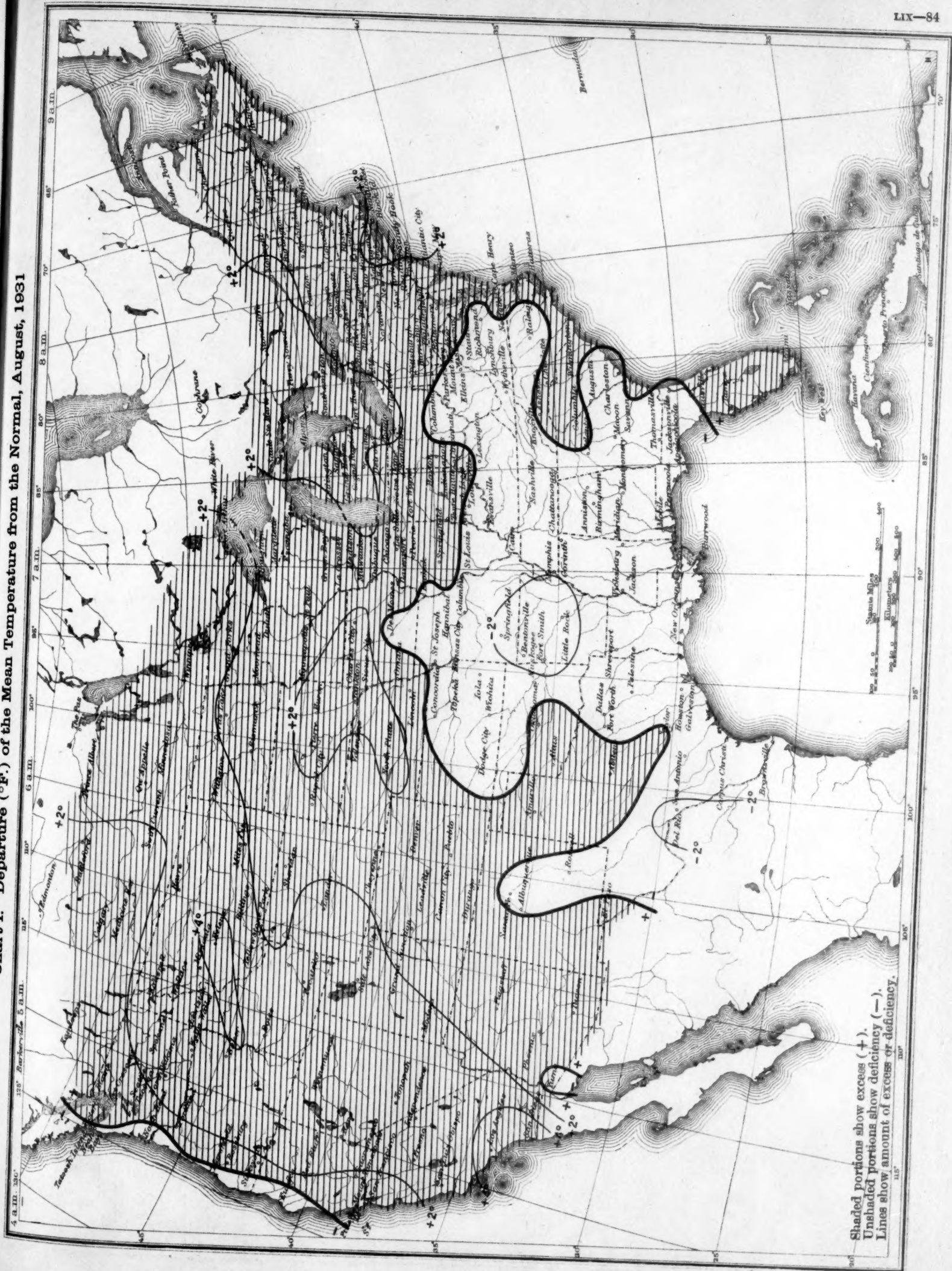
Chart II. Tracks of Centers of Anticyclones, August, 1931. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by G. E. Dunn)

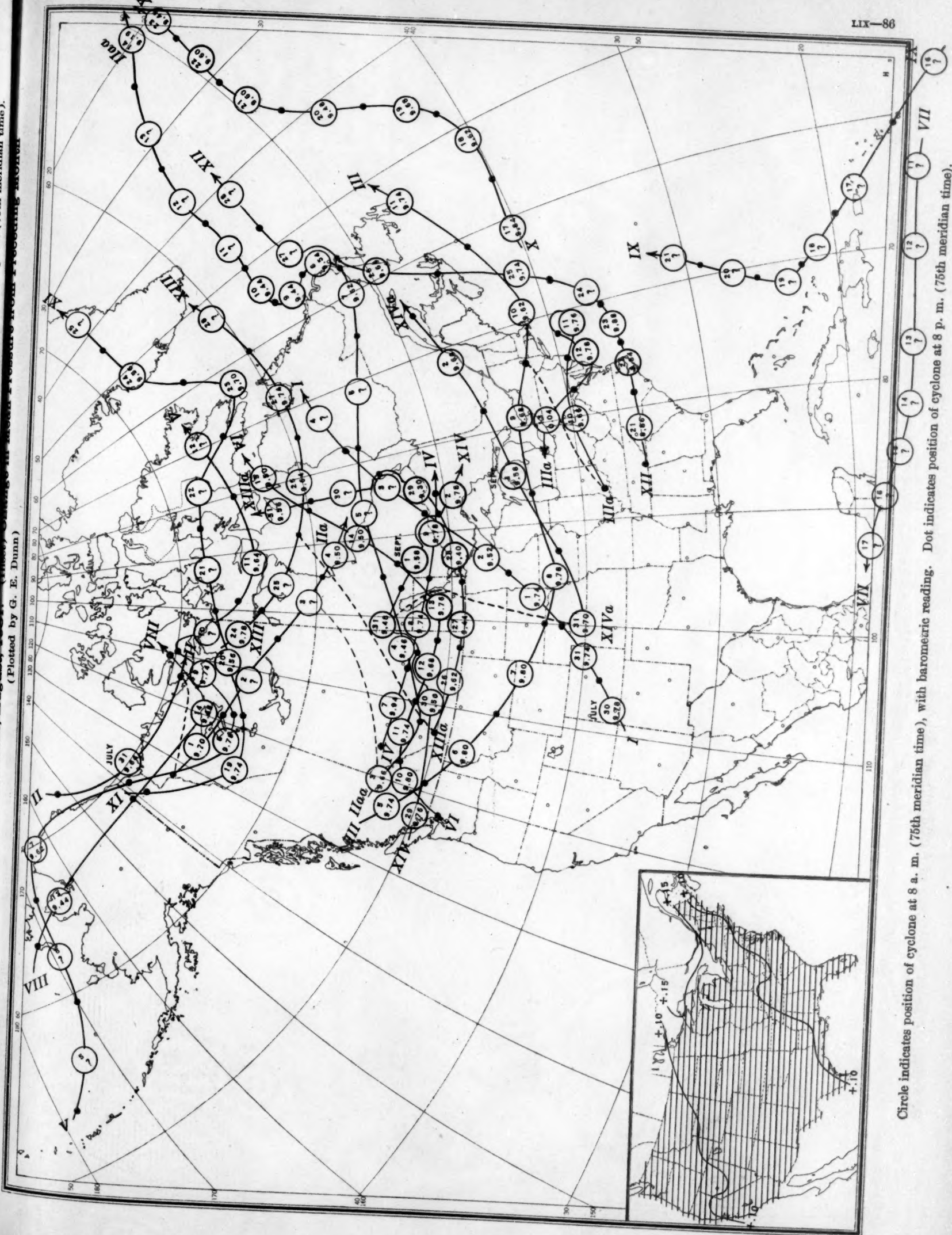Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

(Plotted by G. E. Dunn)

Circle indicates position of cyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 8 p. m. (75th meridian time).

(Plotted by G. E. Dunn)
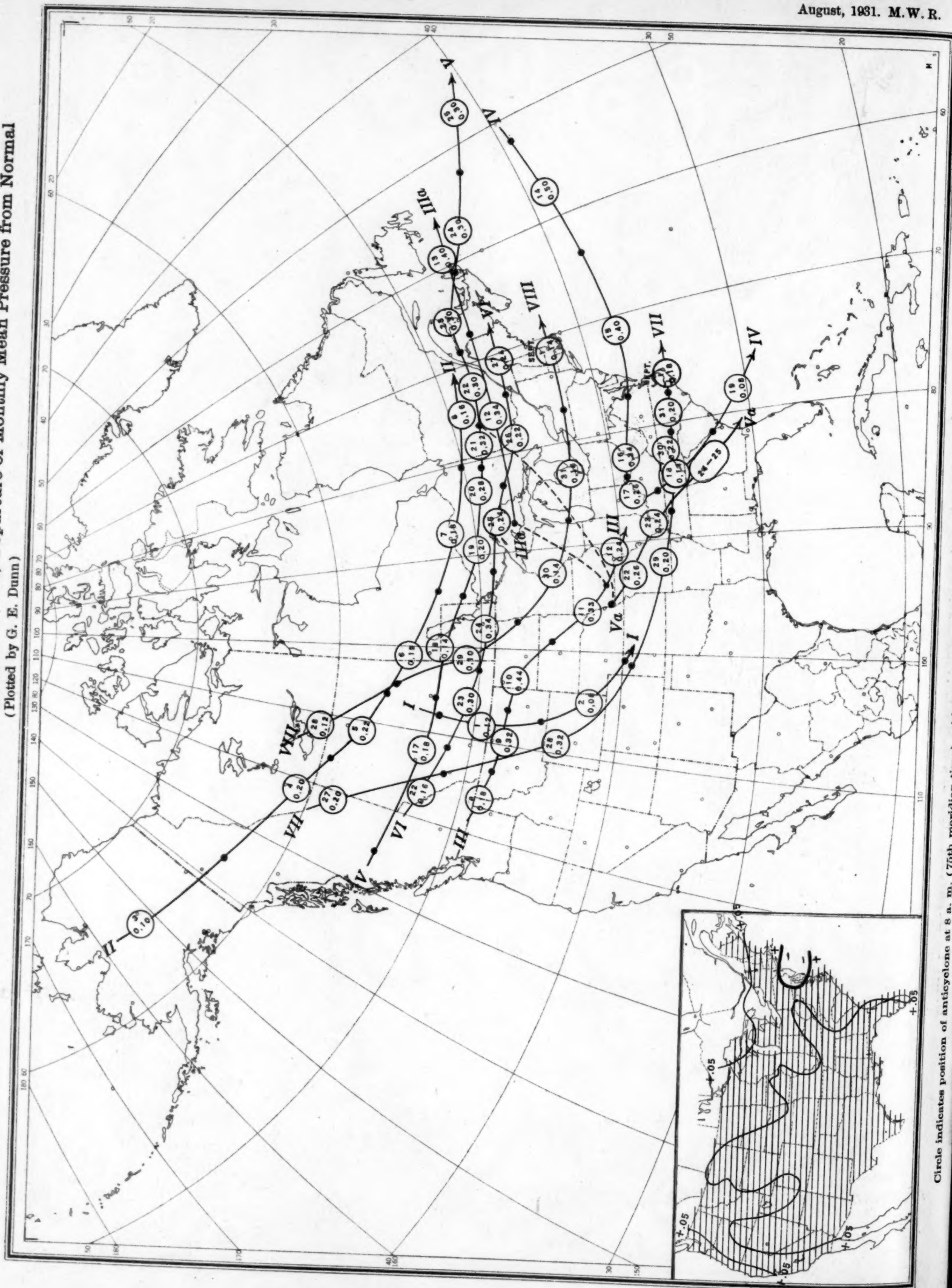
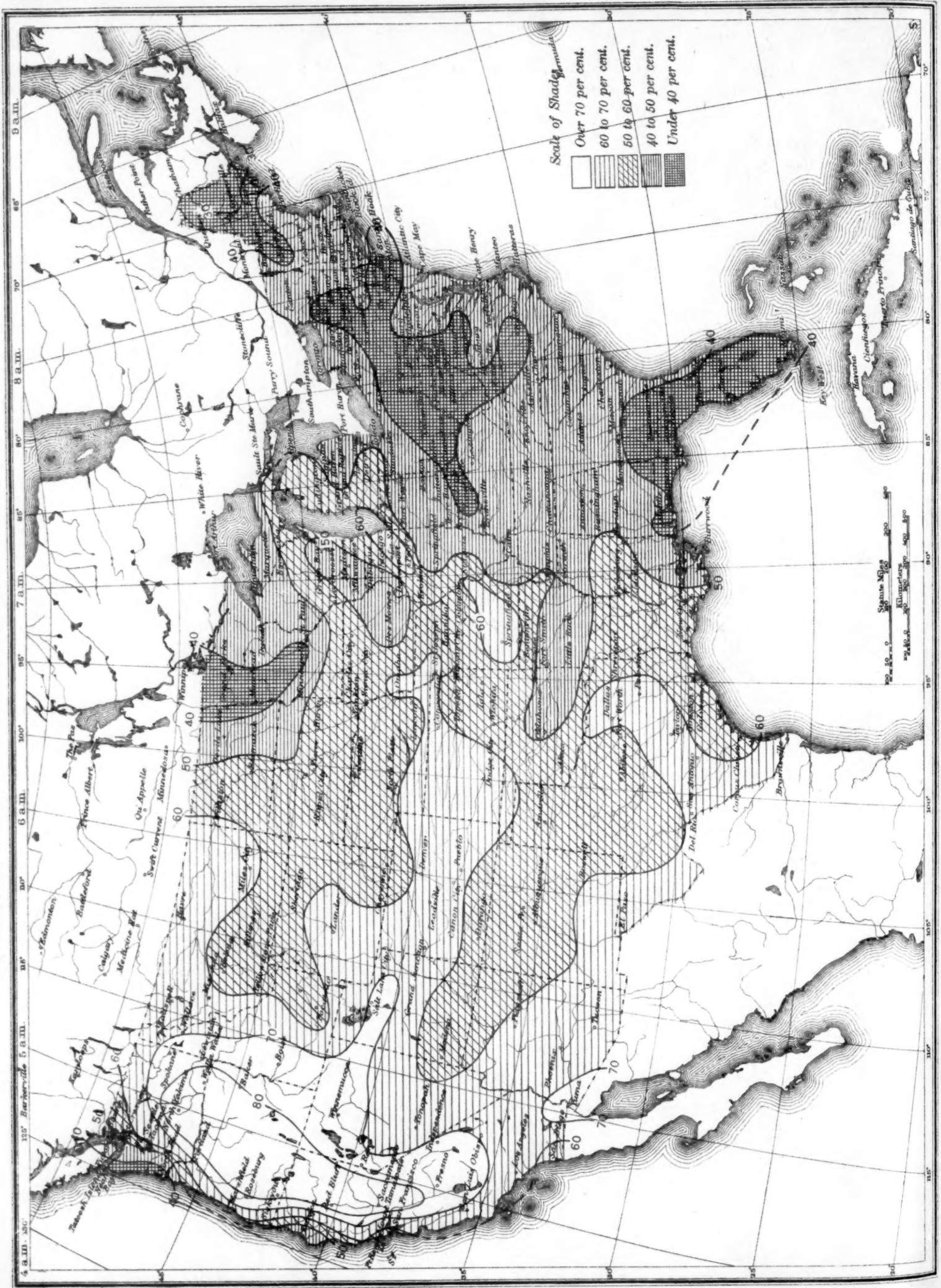Chart IV. Percentage of Clear Sky between Sunrise and Sunset, August, 1931

Chart V. Total Precipitation, Inches, August, 1931. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, August, 1931. (Inset) Departure of Precipitation from Normal

Scale of Shades

0 to 1 inch.
1 to 2 inches.
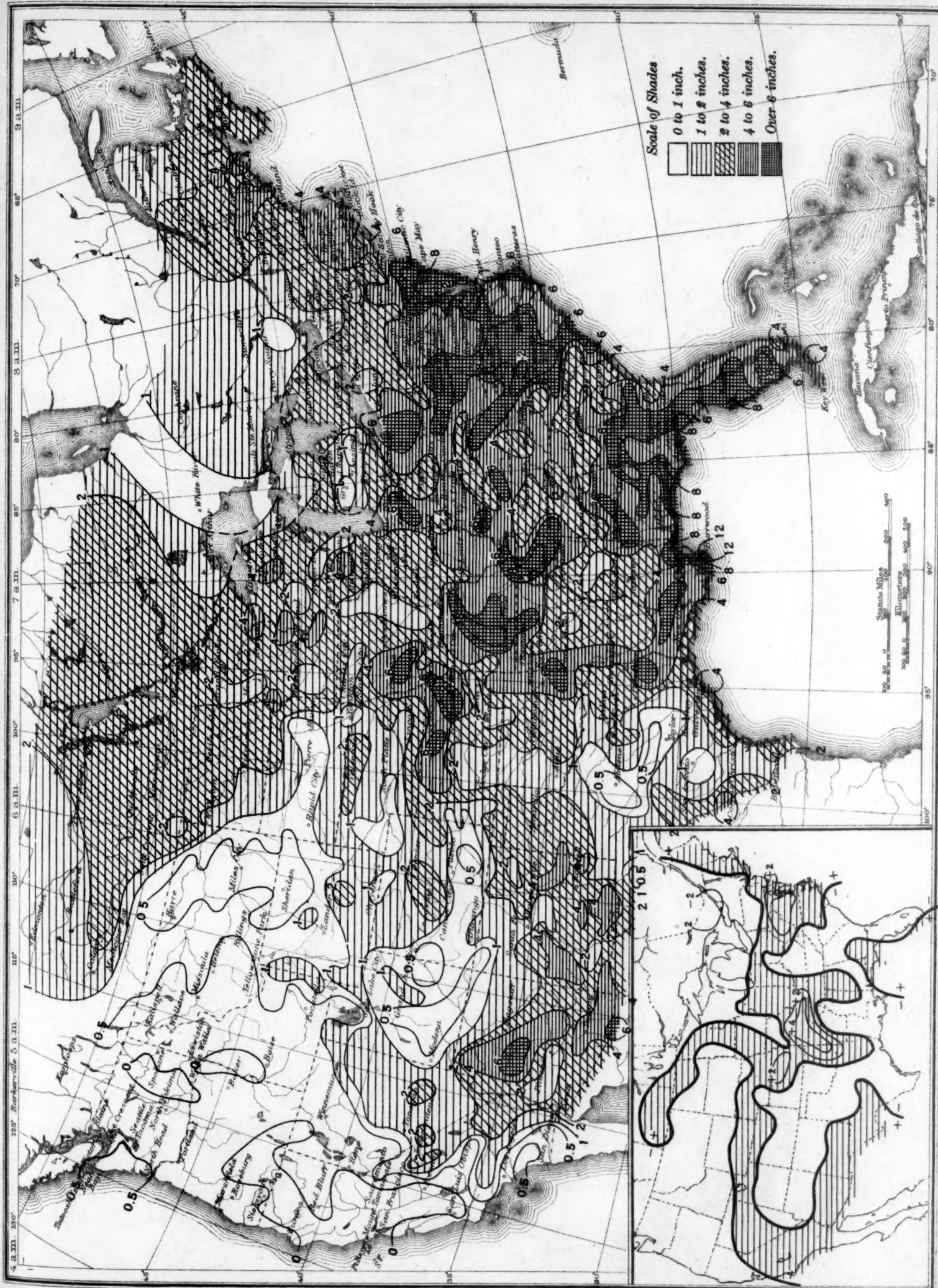2 to 4 inches.
4 to 6 inches.
Over 6 inches.

Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, August, 1931